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WATER QUALITY STUDY

KENOSEE LAKE

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ABBREVIATIONS

BOD	Biochemical oxygen demand (5-day)
Cl	Chloride
COND	Specific Conductivity at 25°
cells/L	cells per litre
DO	Dissolved Oxygen
F. Coli	Fecal Coliforms
Fe	Iron
F. Strep	Fecal Streptococci
g/m^2	grams per square metre
inst	instantaneous
km	kilometres
m	metres
max	maximum

ABBREVIATIONS (continued)

mg/Kg	Milligrams per Kilogram
mg/L	Milligrams per litre
mg/m^3	Milligrams per cubic metre
min	minimum
Mn	Manganese
u^S/cm	microsiemens per centimetre
NH_3-N	Ammonia nitrogen
NO_2+NO_3-N	Nitrate and Nitrite nitrogen
orgs/100 ml	organisms per 100 millilitres
ortho-P	Ortho-phosphorous
ppm	parts per million
% Sat	percent saturation
T°C	Temperature degrees centigrade

ABBREVIATIONS (continued)

T Coli	Total Coliforms
TKN	Total Kjeldahl nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorous
TSS	Total Suspended Solids
VSS	Volatile Suspended Solids
<	Less than
>	Greater than

SUMMARY

An intensive, one year water quality study of Kenosee Lake was initiated in 1979 by the Water Pollution Control Branch. The main objectives of the study were:

1. to provide a baseline record and general description of the lake water quality;
2. to review the findings in terms of the Saskatchewan surface water quality objectives; and
3. to describe the relative richness of the lake with respect to nutrients and organic production (trophic status).

Kenosee Lake is situated amidst the aspen poplar parkland of Moose Mountain Provincial Park in southeastern Saskatchewan. As of 1980, the Kenosee Lake area provided facilities for more than 500,000 visitors per year which included two swimming beaches, five campgrounds, two commercial lodges and over six hundred cottages. Water-based recreation is the primary form of water use at Kenosee Lake.

The development of extensive weed growth and declining water levels form the main water-related concerns for area residents, visitors and administrators.

The water quality features examined during the four seasonal surveys included physical characteristics, general chemistry, bacteria and aquatic biology. The study results were stored, retrieved and summarized using the ESQUADAT and BIODAT computer data systems.

A review of the summarized data was conducted to determine apparent trends and tendencies over time and from station to station. The data were further examined in terms of the provincial surface water quality objectives and to determine the relative richness with respect to nutrients and organic production (trophic status) of the lake.

Mean total phosphorous values measured during this study of Kenosee Lake generally exceeded the Saskatchewan surface water quality objective (0.05 mg/L as P) however, this is not unusual for the naturally nutrient enriched surface waters common to the prairies. Mean total phosphorous concentrations generally reached maximum levels during the winter survey as a result of the release of phosphorous from decaying vegetation and bottom sediments. Mean Ortho-phosphorous values were generally quite consistent at approximately 0.05 mg/L for all seasons of the year. A few elevated Ortho-phosphorous values may have masked the expected trend towards lower mean levels during the open water surveys.

Data pertaining to chlorophyll showed that slight seasonal variations occurred during the study period. Elevated chlorophyll levels recorded during the fall survey may be attributable to the presence of suspended parts of macrophytic plants in the water column since algae blooms were not observed throughout the study period.

The annual mean secchi measurement for Kenosee Lake (mid-lake stations) was 3.0 metres. The lowest mean secchi measurements were recorded during the fall survey.

The prediction of qualitative characteristics (trophic status) of Kenosee Lake employed here followed methods established by Vollenweider and Kerekes (1980). The main components in this classification scheme are average annual lake phosphorous, average annual and peak chlorophyll concentrations and average yearly secchi disk transparency. Extensive growth of aquatic plants (macrophytes) and an infrequent flushing regime limited the applicability of the model results to the Kenosee Lake data. In terms of average annual total phosphourous concentration, peak chlorophyll concentration and average yearly secchi transparency the model predicted a eutrophic or highly productive status for Kenosee Lake. The average annual chlorophyll concentration predicted a mesotrophic status for Kenosee Lake. The different trophic status predicted by the average annual chlorophyll concentration was probably the result of the abundant macrophyte growth and/or other chemical and physical conditions which may limit algae growth in the lake.

Mean total Kjeldahl nitrogen and ammonia nitrogen values displayed seasonal variations and were generally found in highest concentrations during the winter survey. The processes involved in the decomposition of plant material and the formation of ice cover account for the observed trends. Mean nitrate and nitrite nitrogen values also showed seasonal variation and were found in the lowest concentrations during the winter survey. Reduced bacterial nitrification during low water temperature periods accounts for the below detection level nitrate and nitrite values recorded during the winter survey. Mean total organic nitrogen concentrations generally exceeded the surface water quality objectives however, this is not unusual for nutrient rich prairie lakes. Under the winter temperature and pH conditions recorded for Kenosee Lake maximum un-ionized ammonia nitrogen levels were considerably less than the allowable level for individual samples suggested in the USEPA (1983) criteria for the protection of aquatic life.

Phytoplankton results indicated that seasonal changes in the composition of the algae populations were occurring in Kenosee Lake during the study period. During the summer survey the blue-green algae (Cyanophytes) were the dominant taxa present in terms of both quantity and volume. Data from the winter survey showed that the dinoflagellates (Phyrrhophytes) were dominant for both criteria. Phytoplankton densities were found to be highest during the summer and lowest during the winter. Additionally, the greatest number of species present occurred during the summer survey and the least during the winter survey. The pattern of occurrence of blue-green algae species suggests that Kenosee Lake falls within the eutrophic category. Since algae growth was not extensive in Kenosee Lake physical or chemical conditions and/or the abundance of macrophytes may be functioning to limit the growth of algae species typically present in eutrophic prairie lakes.

Data pertaining to indicator bacteria levels in the lake showed that all geometric mean values for total and fecal coliform bacteria were well within the surface water quality objectives concerning recreational use. Generally, fecal streptococci densities were also quite low. Based on the coliform indicator bacteria data the waters of Kenosee Lake were satisfactory for direct contact recreation. Additionally, the prevalence of low levels of fecal streptococci bacteria shows that little or no pollution from agricultural or wildlife sources was evident during the Kenosee Lake study.

Dissolved oxygen concentrations during the summer and fall surveys were consistently above the surface water quality objective of 5.0 mg/L. Winter survey results showed that mean dissolved oxygen concentrations for depths greater than 2.0 metres were less than the objective (5 mg/L) for protection of aquatic life. These results show that in parts of Kenosee Lake there existed the potential for winter fish kills due to oxygen depletion. During the spring survey all mean dissolved oxygen concentrations were satisfactory. However, 18 per cent of the individual recordings during the spring survey were below the objective for protection of aquatic life. Diurnal studies indicate that the potential did exist for night-time oxygen depletions in shallow areas during the spring survey. The absence of dissolved oxygen and temperature stratification combined with other chemical data suggests that Kenosee Lake remains well mixed throughout the year.

Spring and summer total organic carbon concentrations for Kenosee Lake approached the upper limit of the environmental range of 1 to 30 mg/L for natural surface waters (McNeely, Neimanis and Dwyer, 1979).

Phytoplankton and abundant macrophyte growth may account for the elevated total organic carbon concentrations. The lowest total organic carbon values which occurred in the fall may have been due to reduced contributions from phytoplankton and macrophytes and more carbon being bound in plant growth immediately prior to the onset of vegetative degradation.

Slight spatial variations were apparent in the biochemical oxygen demand data for the August survey and may have resulted from photosynthetic activities of macrophytic plants at near shore locations.

Suspended solid concentrations reported for Kenosee Lake generally met the objective (25 mg/L) for a high level of protection of an aquatic community. Additionally, suspended solids did not reach concentrations which would impair water clarity for recreational use. Suspended solid concentrations were generally highest at the shallow stations probably as a result of shoreline erosion and the resuspension of bottom sediments by wave action.

The pH values recorded for Kenosee Lake generally exceeded the provincial surface water quality objective range (i.e. 6.5 to 8.5) however, the values were comparable to those for other lakes in the immediate area. The pH values were slightly lower during the winter survey presumably due to ice cover, acidity associated with decomposition by-products and increased carbon dioxide levels in the water.

Conductivity recordings (range) indicated that Kenosee Lake falls within the slightly saline classification. The slightly saline condition of the lake is probably the result of the accumulation of dissolved solids over time by evaporation, ground water inflow, low water levels and minimal outflows from the lake basin. The conductivity values also exhibited a general trend towards elevated levels during winter months and elevated levels at the deeper mid-lake stations during the summer and winter surveys. Concentration of dissolved solids by ice formation probably accounts for the higher winter conductivity values.

Chloride data for Kenosee Lake exhibited slight seasonal variations. Seasonal trends in chloride concentration were probably dependent on concentration by ice formation and the increased significance of ground water inputs during winter months, evaporation over the summer months and, surface runoff which was generally less than expected prior to and during the study period. The lack of discernable spatial trends in the chloride data indicates that pollution from domestic sewage was insignificant or not detectable by the sampling program. Iron and manganese concentrations generally equalled or were within the respective surface water quality objectives of 0.03 mg/L and 0.05 mg/L.

The macrophyte survey showed that extensive growth of aquatic plants was occurring, especially in regions of the lake with depths of four metres or less. The data pertaining to the phosphorous content of macrophytic plants collected during August, 1979, indicated that about

5.2×10^3 Kg (fresh weight) of phosphorous was associated with living plants in the lake. Theoretically, the abundant growth of aquatic plants with the associated uptake of phosphorous combined with other physical and chemical conditions may function to partially limit algae growth during summer months.

The examination of the bottom fauna revealed high mean standing crop values of approximately 2500 orgranisms/metre^2 and an aquatic fly (midge and phantom midge) and snail dominated population. These results indicated that Kenosee Lake was within the eutrophic category in terms of bottom fauna. A spatial trend was apparent in the occurrence of several types of bottom dwelling aquatic organisms for locations with differing water depths.

The results of pesticide and trace metal analysis of fish muscle tissue were all within the available consumptive guidelines. Based on the limited data yellow perch and northern pike were safe for human consumption.

RECOMMENDATIONS

1. Future Monitoring

The results of the 1979-80 study provide baseline general water quality data and an assessment of the trophic status of Kenosee Lake. In order to ensure that the use potential of Kenosee Lake does not become impaired beyond its present state another indepth study should be conducted at some future date. In reassessing the water quality of the lake, this future study could determine if any changes have occurred since the 1979-80 investigation. Future monitoring should re-examine the water quality parameters addressed in the present study.

2. Dissolved Oxygen

Results of the Kenosee Lake study indicate that a reduction in the dissolved oxygen concentration occurred during the ice cover period and that the potential for winter fish kills did exist within parts of the lake. Further study of the dissolved oxygen conditions during the late winter period should be conducted to obtain information for assessing the likelihood of fish kills due to oxygen depletion.

3. Fish

The results of the Kenosee Lake study indicate that the game fish tested were within the consumptive guidelines however, the conclusions were based on a small number of samples. Additional monitoring of mercury in the game fish species present in the lake should be undertaken in order to reaffirm their consumptive quality.

1. INTRODUCTION

The intensive water quality study of Kenosee Lake was undertaken by Saskatchewan Environment in response to several water quality concerns. Among these water quality concerns the greater possibility of pollution of Kenosee Lake existed due to increasing recreational use and subsequent shoreline development. The potential for nutrient pollution from agricultural sources and domestic sewage disposal practices was receiving greater attention from local residents. The occurrence of partial fish kills suggested that the nature of the lake may have been changing. Additionally, the reported increase of macrophytic and planktonic growth warranted further study.

1.1 Objectives and Scope

The basic objectives of the Kenosee Lake study were:

1. to provide a baseline record and general description of the lake water quality;
2. to review the findings in terms of the Saskatchewan surface water quality objectives; and
3. to describe the relative richness of the lake with respect to nutrients and organic production (trophic status).

2. BACKGROUND

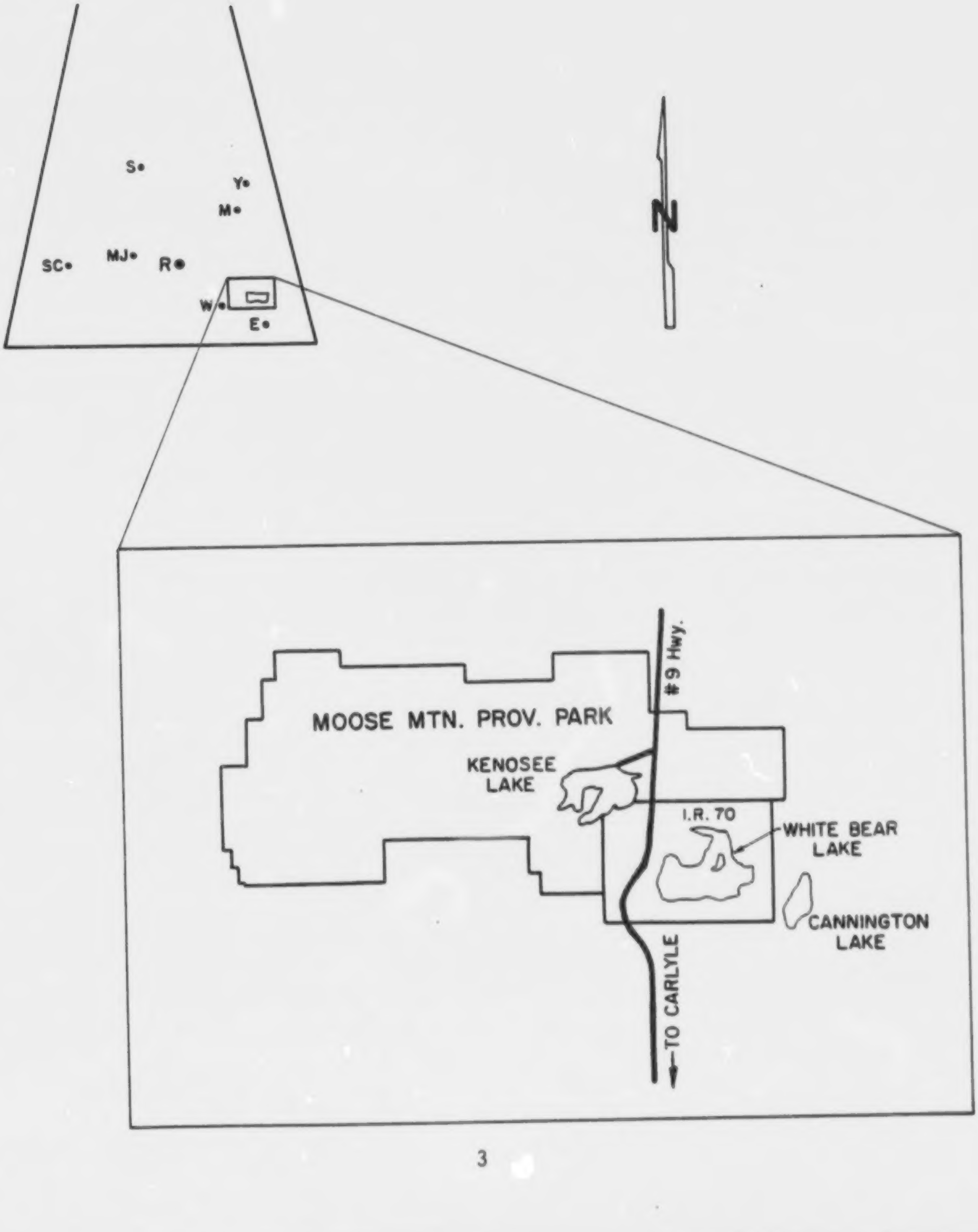
2.1 Geography, Topography, Geology and Climate

Moose Mountain Provincial Park was established in 1931 and covers 399 square kilometres (154 square miles) of Southeastern Saskatchewan (Royer, 1962). Kenosee Lake is situated admist the aspen-poplar parkland of Moose Mountain Provincial Park (Figure 1). The area rises from 60 to 150 metres above the surrounding prairie with a maximum elevation in access of 830 metres above sea level.

The topography of the park area features rolling hills (knobs) with numerous small lakes and sloughs in the depressional areas (kettles). Gray Podzolic soils are dominant in the region (Richards and Fung, 1969). A description of the geological history provides an aid in understanding the topography of Moose Mountain Provincial Park.

Christiansen's (1956) study showed that the entire area was once covered with glacial ice. Melting of the thin overlying ice and the deposition of dead ice morrains resulted in hummock land formations. Many of today's sloughs and small lakes were formed by the gradual melting of the older, thicker ice in the depressions. The ice sheets surrounding the present park separated and retreated in two parts: the Moose Mountain Lobe along the north side and the Weyburn Lobe along the south side.

Figure I KENOSEE LAKE LOCATION



The climate of Moose Mountain Provincial Park is described as a "dry sub-humid" type according to Thornthwaite's 1948 classification scheme (Richards and Fung, 1969). Data regarding the annual precipitation and mean temperatures are available for Carlyle, Saskatchewan, which is located approximately 20 kilometres south of Kenosee Lake. The elevation difference between Carlyle and Kenosee Lake probably results in greater precipitation and lower temperatures at the lake, but the extent of these differences is not known. Figure 2 depicts the mean annual high and low temperatures and total annual precipitation for Carlyle, Saskatchewan.

2.2 Morphometry and Hydrology

Kenosee Lake is the largest lake within Moose Mountain Provincial Park. The surface area of the lake is 770 hectares with a shoreline of 23.4 km excluding islands. Islands at the east end of the lake account for an additional 6.6 km of productive shoreline. The bathymetric map of Kenosee Lake presented in Figure 3 plots the maximum depth of 9.1 metres charted during an August, 1979, survey. The 1979 mean depth was calculated to be 4.2 metres (Christensen, 1980). The present assumed full supply level of Kenosee Lake is 742.2 metres (Aaston, 1983).

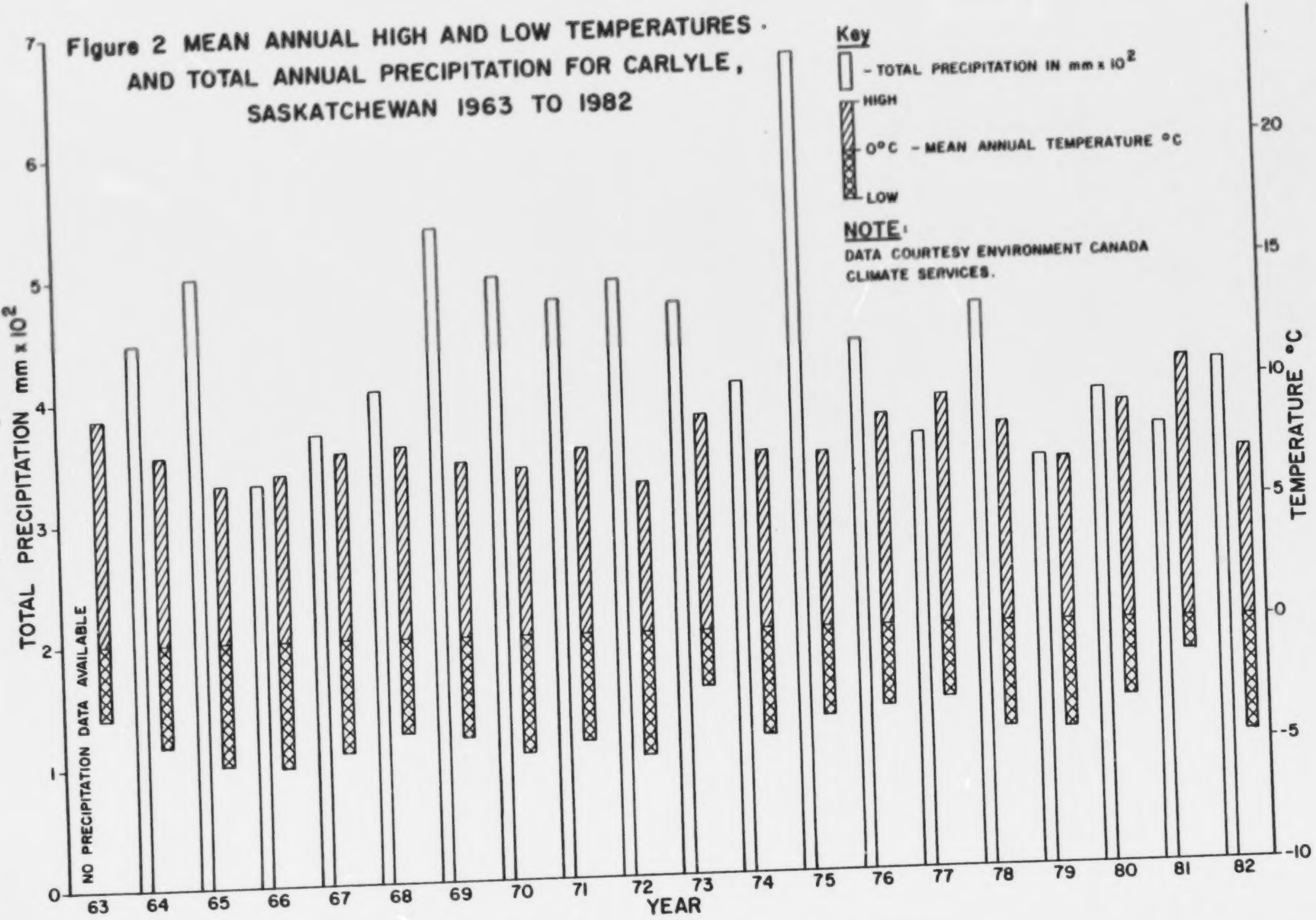
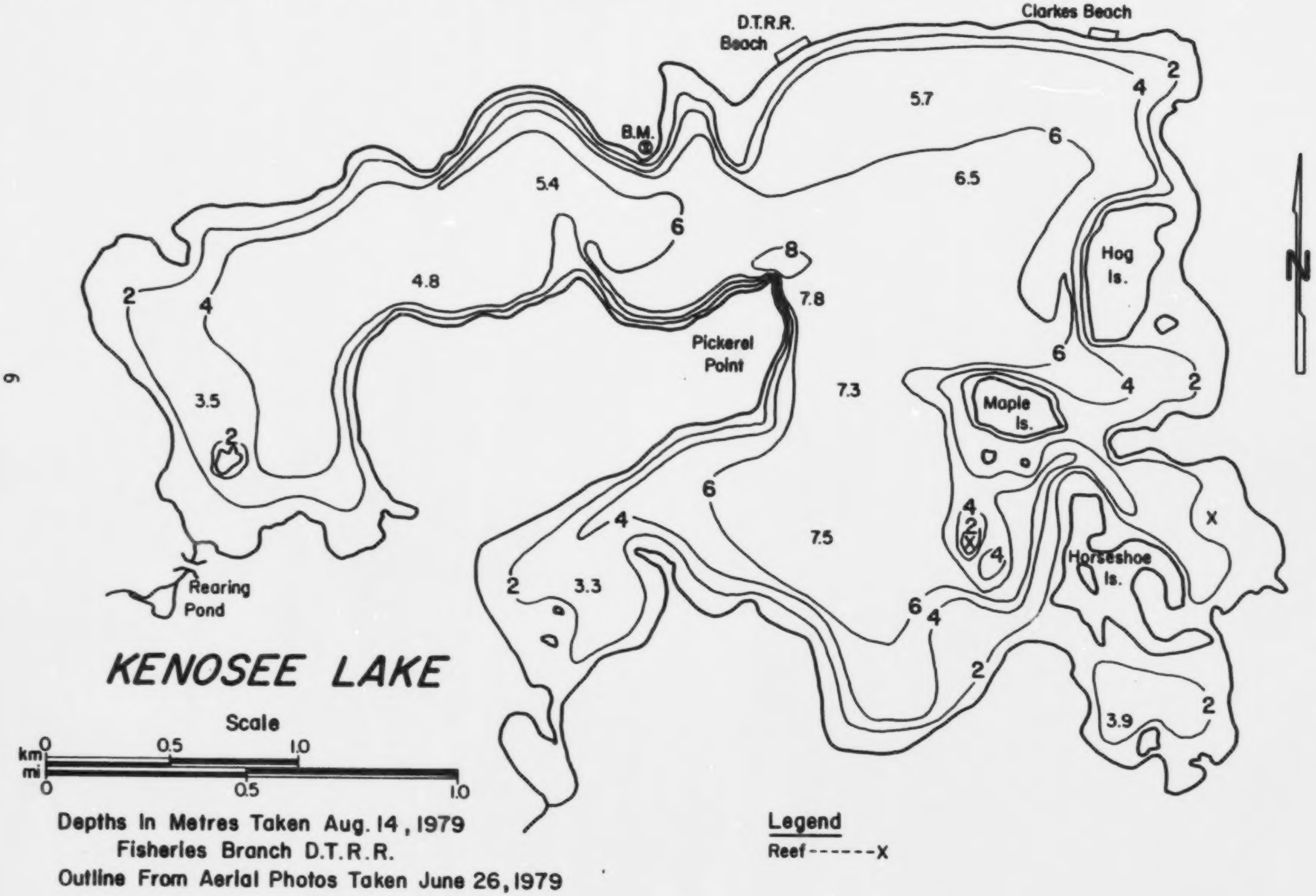


Figure 2 MEAN ANNUAL HIGH AND LOW TEMPERATURES AND TOTAL ANNUAL PRECIPITATION FOR CARLYLE, SASKATCHEWAN 1963 TO 1982

Figure 3 BATHYMETRIC MAP OF KENOSEE LAKE



Water levels of Kenosee Lake have been reviewed by Connel (1962), Parsons (1965), Meneley and Whitaker (1970), Redshaw (1970) and Smith (1974). Parsons (1965) noted that Kenosee Lake water levels may be expected to normally fluctuate up to 10 feet (3 metres). Redshaw (1970) found that Kenosee Lake had not reached its overflow level of 742.2 m since 1928. Smith (1974) reported that water from Kenosee Lake had not overflowed to White Bear Lake since 1954. Meneley and Whitaker found that both Kenosee and White Bear Lakes are replenished mainly by ground water discharge rather than by overland runoff. Furthermore, the hydrologic system of the lakes is apparently in dynamic equilibrium with the climate of southeastern Saskatchewan (Meneley and Whitaker, 1970). These studies indicate that lake levels may be expected to fluctuate markedly between extremes of climate experienced in the area.

Redshaw (1970) determined the effective drainage area of Kenosee Lake to be 20.7 square kilometres and the gross drainage area to be 151.5 square kilometres. Unfortunately the gross drainage basin of Kenosee Lake is poorly defined with dense vegetation covering the natural waterways. As a result, overflow from many of the small depressional areas will only reach Kenosee Lake after a series of years with high runoff and low summer evaporation.

Incomplete water level records are available for Kenosee Lake since 1964. Table 1 depicts the monthly mean water levels for Kenosee Lake.

Table 1

MEAN MONTHLY WATER LEVELS FOR KENOSEE LAKE 1967-1982

(water level in metres above sea level)

Year	April	May	June	July	August	September	October
1967	-	-	-	739.640	739.475	-	-
1968	-	-	739.373	-	-	-	-
1969	-	-	740.301	-	740.368	-	-
1970	-	-	739.933	793.872	739.808	-	-
1971	-	-	739.827	739.815	-	-	-
1972	-	-	739.819	739.751	739.746	739.665	739.598
1973	-	-	-	739.624	739.559	739.536	-
1974	-	-	739.819	739.710	739.591	739.549	-
1975	-	-	739.837	739.814	739.737	739.833	-
1976	-	740.251	740.249	740.180	740.093	739.991	-
1977	-	-	739.841	739.749	739.644	739.609	-
1978	739.651	739.685	739.648	739.625	739.502	739.454	739.436
1979	739.495	739.614	739.650	739.595	739.512	739.477	739.387
1980	739.474	739.423	739.313	739.258	739.246	739.205	739.149
1981	739.142	739.088	739.067	738.985	738.916	738.833	739.822
1982	-	738.958	738.906	738.840	738.806	738.732	-

2.3 Land Use

Moose Mountain Provincial Park has consistently been the most popular provincial park in Saskatchewan, attracting over 500,000 visitors per year since 1972 (Prier, 1980). Recent park attendance figures for summer months (May through September) from 1977 to 1983 are presented in Table 2. The high attendance trends reflect considerable use by persons from outside of the immediate area. With such high usage rates there is an increased potential for pollution of Kenosee Lake.

Table 2
MOOSE MOUNTAIN PROVINCIAL PARK -
ATTENDANCE FIGURES 1977 to 1983

Year	Number of Persons Entering Park Through Main Gate (May through September)
1977	629,560
1978	618,536
1979	611,848
1980	666,052
1981	625,492
1982	628,584
1983	569,024

Water based recreational activities enjoyed on Kenosee Lake include: fishing, boating, sailing, water skiing, swimming and diving. The Kenosee Lake area provides facilities that include two swimming beaches, five campgrounds containing 623 campsites, two commercial lodges and numerous other amenities. The lake also supports 640 cottages at eight different sites (Prier, 1980).

2.4 Historical Water Quality Studies and Concerns

The water quality of Kenosee Lake has been studied to various degrees since at least 1938 when Lawson and Moore (1944) reported on the lake salinity. Major ions, dissolved oxygen concentrations and temperature profiles were reported by Hamilton (1961) and Royer (1962) from data gathered during the 1960 Moose Mountain Lakes investigation. Rozkowski (1969) reported studies on Kenosee Lake concentrating mainly upon salt chemistry. Meneley and Whitaker's (1970) study of the Geohydrology of the Moose Mountain Upland includes data on groundwater quality. Smith (1974) reviewed the water quality information previously collected by other researchers. Cullimore and Griffin (1979) reported on all available information relevant to the water quality of White Bear Lake which is located downstream of and adjacent to Kenosee Lake in the Moose Mountain Highland area.

Prier (1980) noted three water-related problems regarding Kenosee Lake. These were: low water levels effecting recreational boating; algae and/or weed growth effecting sport fishing and; other non specific water pollution concerns.

Aaston (1983) attributed the deterioration of water quality in Kenosee Lake as being mainly due to the decline in water levels and to a lesser extent by nutrients originating from cottage and agricultural areas within the watershed.

Sewage disposal facilities at the dwellings surrounding Kenosee Lake have not been extensively surveyed prior to the study. Generally, sewage disposal at seasonal cottages consists of pit privies or septic tanks. Prior to and during this study septic tank wastes from the resort village of Kenosee Lake (formerly the resort village of We-Non-Cha), from the provincial park campgrounds and other residences were hauled to a lagoon system maintained by the provincial park. This facility consisted of a 2 cell lagoon just northeast of the village located at NW 24-10-3-W2.

A new sewage treatment and effluent irrigation system located at SE 18-10-2-W2 consisting of a force main and a treatment cell was constructed during the summer of 1981 (Saskatchewan Environment, 1981). A holding cell at the new site was constructed during 1984 and is presently receiving wastes from the resort village and park facilities (per. comm. G. Wyatt, Department of Parks and Renewable Resources, November, 1984).

Agricultural use of the surrounding watershed primarily involves cattle ranges and hay production. The quality of surface waters in these locales and their impact on Kenosee Lake has not been investigated to date.

A sport fishing management study by Snell (1978) notes that very dense weed growth had developed between 1975 and 1978 in areas of Kenosee Lake which ranged in depth from 2.75 m (9 feet) to 5.5 m (18 feet). Snell (1978) noted that the possibility of summer fish kills exists after sunset, particularly during cloudy weather. Snell (1979) also reported the occurrence of a partial fish kill of perch, pike, suckers and walleye during the winter of 1978 to 1979 presumably due to low oxygen levels.

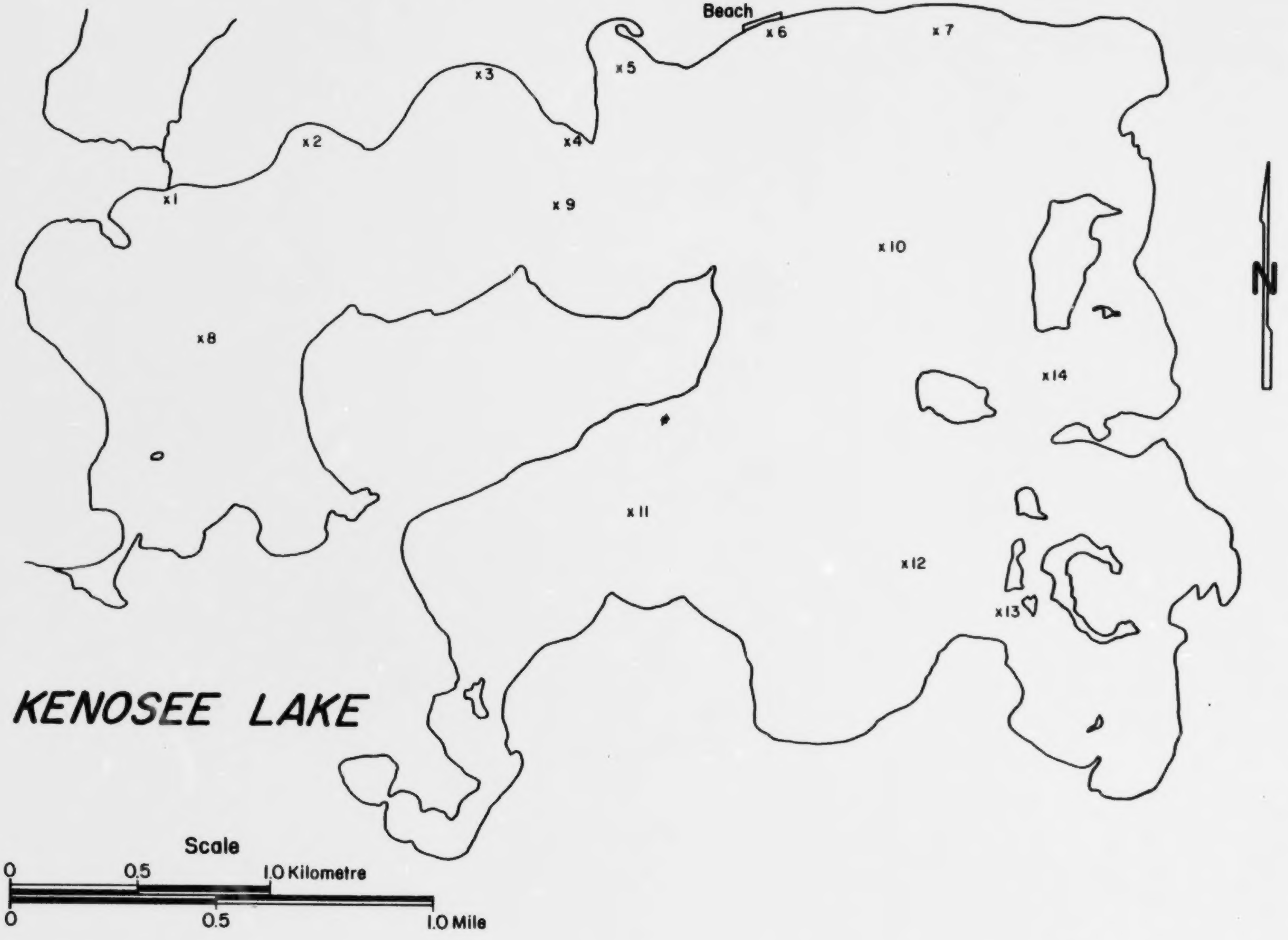
3. WATER QUALITY SURVEILLANCE ACTIVITIES

The Water Pollution Control Branch (WPCB) of the Saskatchewan Environment in cooperation with the Fisheries Branch of the Department of Parks and Renewable Resources (formerly Department of Tourism and Renewable Resources) undertook the field study portion of the Kenosee Lake intensive recreational lake survey during the period July,1979 to May, 1980. The water quality aspects examined during the field study included: physical, chemical and bacteriological water quality; phytoplankton; macrophytes; benthos; and fish.

The initial design of the Kenosee Lake intensive recreational lake survey included a total of 14 sampling stations. Stations 1 through 7 were located along the developed side of the lake at a distance from the shore such that the water depth was 1.0 to 1.5 metres. Stations 8 through 11 represented the main basin areas of the lake. Station 13 represented the shallow southeast end, while station 12 was in a deeper weed-free area. Station 14 was located at a relatively deep area where trolling for fish was commonly practiced. Figure 4 depicts the locations of the Kenosee Lake sampling stations.

Four seasonal water quality surveys were conducted by W.P.C.B. personnel on August 13 - 15, 1979 (summer), October 22 - 24, 1979 (fall), February 18 - 20, 1980 (winter) and, May 26 - 28, 1980 (spring).

Figure 4 KENOSEE LAKE SAMPLING STATIONS



3.1 Water Quality Parameters

3.1.1 Physical Parameters and Field Measurements

Included in a list of physical parameters and field measurements studied during the Kenosee Lake survey were: dissolved oxygen; temperature; pH; specific conductance; and secchi disk depth. Appendix A, Table A-1 summarizes the proceedural details regarding the determinations of physical parameters and field measurements. Detailed technical methods employed by staff members for the above mentioned measurements are available from the WPCB procedures manual (Saskatchewan Environment, 1977a).

3.1.2 Chemical and Bacteriological Parameters

The collection and analysis of water quality samples for the Kenosee Lake intensive recreational lake survey was separated into diurnal and consecutive day sampling categories. In some instances the same water sample was submitted for the analysis of the parameters important to each category. Diurnal water quality sampling of Kenosee Lake was carried out on the first day only of the August 13-15, 1979 and the May 26-28, 1980 surveys. Single diurnal samples were collected every four hours from each station with two of the sample times as close as practical to sunrise and sunset. Additionally, consecutive sampling was performed for these surveys during daylight hours at each station on the following 2 days. Consecutive day water quality samples were collected for 3 days during the fall and winter surveys.

Water quality samples collected during the surveys were submitted according to the parameter groupings for which analysis was required. Appendix A, Table A-2 describes the water quality parameter groupings used for the Kenosee Lake survey. Analyses for group 1 parameters was performed on all diurnal and consecutive day samples. Analysis for groups 2 and 3 was performed on one sample (consecutive day sample) per day. Detailed descriptions of water quality sampling procedures employed during the Kenosee Lake study are available from the WPCB procedures manual (1977a). References to composite samples means that manually mixed aliquots constituted the composite sample. These aliquots were obtained from various depths depending on the total depth, temperature and dissolved oxygen conditions. Samples from near shore stations were generally collected at mid-depth only since the lake was less than 3 metres deep at these locations.

Analysis for all chemical and bacteriological parameters was performed by the Provincial Laboratory in Regina. Analytical methodology followed established procedures as described in the Esquadat dictionary of Parameter Codes (Saskatchewan Environment 1977b). Appendix A, Table A-3 provides the Esquadat procedure description reference numbers for all chemical and bacteriological parameters for which analyses were performed on the Kenosee Lake samples.

3.2 Phytoplankton

Phytoplankton samples collected during open water surveys were limited to a single sample from each station during each of the August 1979, October 1979, and May 1980 surveys. Phytoplankton samples collected during the February 1980 survey consisted of one sample from each station during each day of the 3 day surveys. In all instances, phytoplankton samples were taken from the composite water quality samples collected for the surveys. Samples consisted of 50 millilitre water samples preserved with approximately 0.5 millilitres of Lugol's solution.

Analysis of the phytoplankton samples included enumeration and identification to the lowest possible taxonomic level (e.g. species, genus or family). Furthermore, a species present list was also included for portions of the samples not included in the enumeration process. Some of the taxonomic references used during the algae identification include: Bourrelly (1968), Bourrelly (1970), Bourrelly (1972), Hustedt (1930), Komarkova-Legnerova (1969), Prescott (1962), Tiftany and Britton (1971) and Uherkovitch (1966).

3.3 Macrophytes

The macrophyte survey of Kenosee Lake was conducted in two parts: an aerial photographic survey and; a surface/subsurface study of plant growth.

The aerial photographic survey was conducted on July 31, 1979 to determine the broad zones of macrophyte growth in Kenosee Lake. Photographs of the lake area were taken along four aerial transects as depicted in figure 5. The surface proofing of the aerial survey was based on a series of spot transect macrophyte descriptions. Skin diving techniques were employed to perform the macrophyte descriptions along 6 surface transects during August 2-3, 1979 and August 14, 1979 surveys. The locations of the surface transects and sampling spot locations are depicted in Figure 6.

Figure 5 AERIAL TRANSECTS FOR MACROPHYTE SURVEY (JULY 31, 1979)

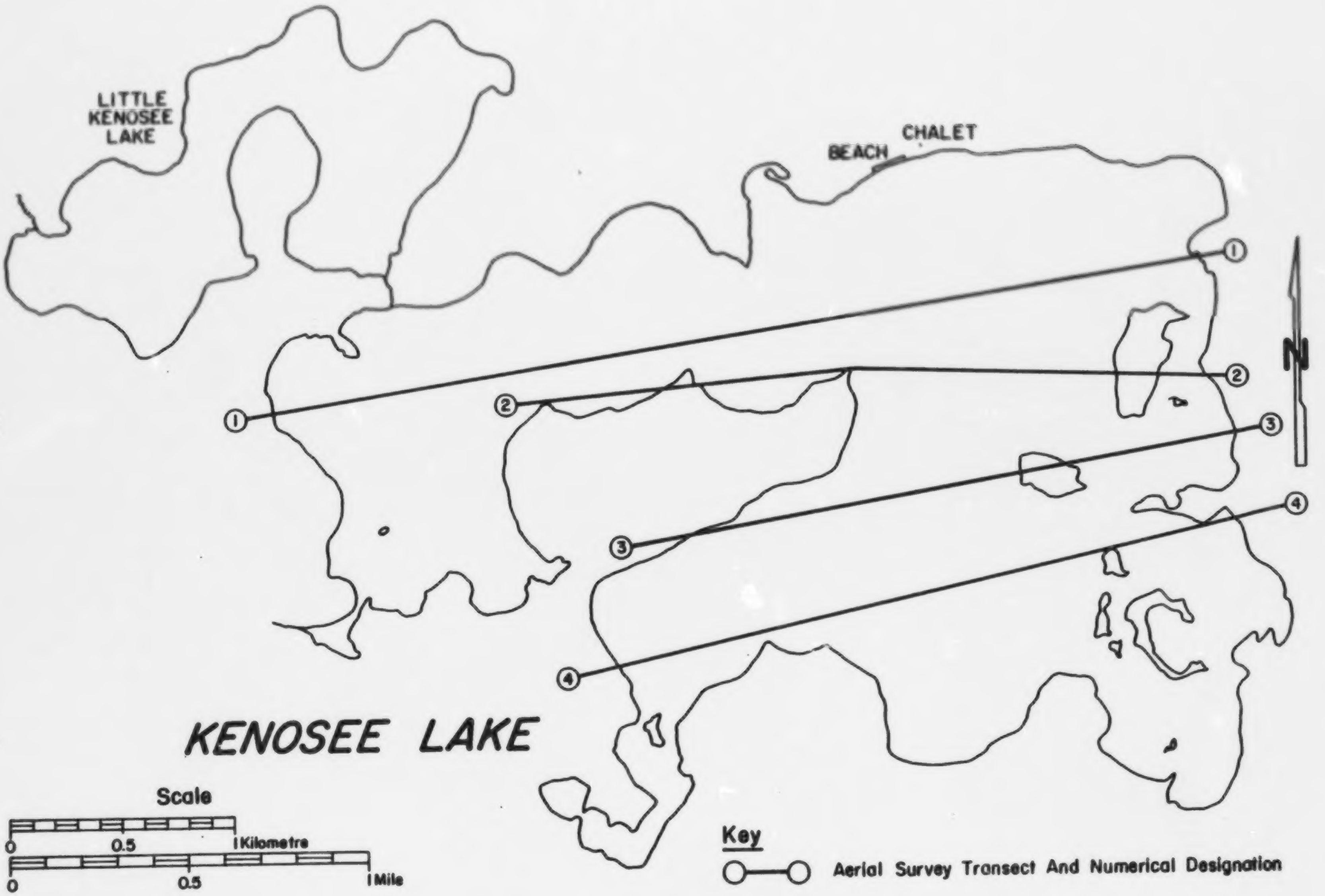
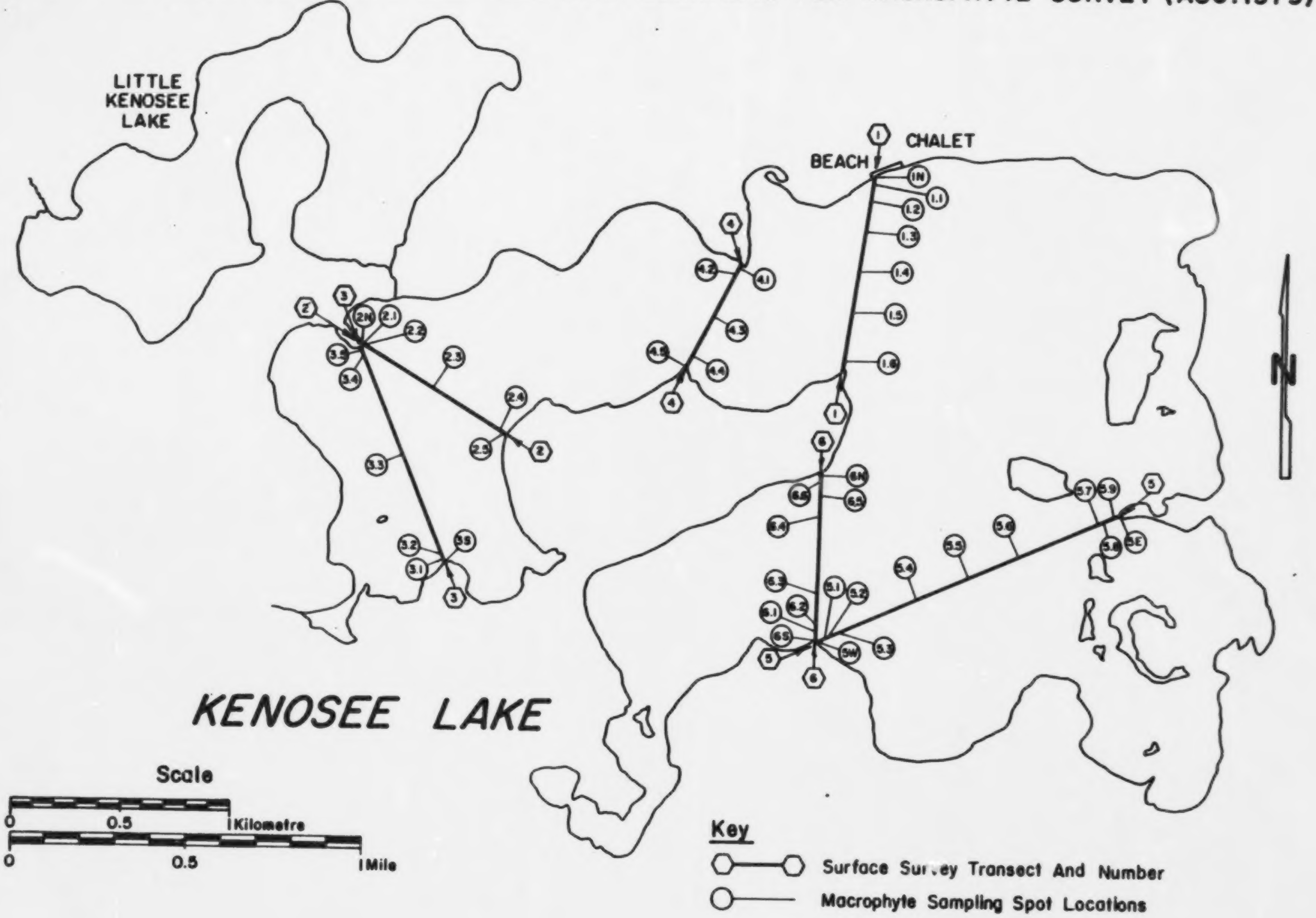


Figure 6 SURFACE TRANSECTS AND SAMPLING LOCATIONS FOR MACROPHYTE SURVEY (AUG. 1979)



The macrophyte surface and subsurface surveys generally included: a plant species field identification; a subjective description of the relative abundance of plant life; a description of the bottom sediments; the measurement of dissolved oxygen and temperature profiles and; secchi depth measurements at some locations.

In addition to the above noted macrophyte survey, the Fisheries Branch of the Department of Parks and Renewable Resources (formerly Department of Tourism and Renewable Resources) conducted a small scale limnological and macrophyte survey on August 17, 1979. This survey involved: a study of the standing biomass of submerged plants using Eckman Dredge sampling techniques; a determination of the phosphorous content of submerged weeds and; some limited chemical and physical water quality monitoring.

3.4 Benthos

The benthos sampling survey for the Kenosee Lake study was conducted on August 14, 1979. Samples were obtained with the use of a Eckman dredge from stations 1, 2, 3 and 8 through 14 inclusive. Shortly after collection, the bentic organisms were sorted from the extraneous material using standard sieves. Benthos samples were then preserved with 37% Formaldhyde in glass vials and submitted to the

Saskatchewan Research Council for identification and enumeration.

3.5 Fish

The fish sampling for the Kenosee Lake intensive recreational lake survey was conducted by the Fisheries Branch of the Department of Parks and Renewable Resources during their August 17, 1979, survey. Gill nets were set out to obtain the samples for heavy metal and pesticide analysis of fish muscle tissue. Specimens of walleye, northern pike and yellow perch were desired for the fish sampling program. Fish samples were submitted to the Freshwater Institute of Environment Canada in Winnipeg, Manitoba, for analysis. The parameters for which analysis of fish muscle tissue was conducted included: mercury; cadmium; lead; copper; zinc; chromium; arsenic; nickel; selenium; total PCBs; total DDT; Dieldrin; Methoxychlor and Lindane.

4. RESULTS AND DISCUSSION

4.1 Eutrophication

Eutrophication is the response in water due to over-enrichment by nutrients, primarily phosphorous and nitrogen, and can occur under natural or man-made conditions. "Man-made" eutrophication, in the absence of control measures, proceeds at an accelerated rate compared to the natural phenomenon and is one of the main forms of water pollution.

An increase in fertility in affected lakes and reservoirs may directly or indirectly cause symptoms such as algal blooms, heavy growth of rooted aquatic plants, algal mats, deoxygenation and, in some cases, unpleasant odour, which often affects most of the important uses of the water such as water supply, fisheries, recreation or aesthetics. Due to these changes, lakes become unattractive for bathing, boating and other water oriented recreations and may result in economic loss to established resorts.

The trophic state of a lake is a characteristic resulting from the interaction and relationship of many physical, chemical and biological factors. These factors have been redefined by many investigators into a variety of physical, chemical and biological dimensions which may be used in arriving at an integrated statement of the trophic state of an individual body of water. The trophic state or condition of a body of water describes its relative richness with respect to nutrients and organic production.

Nutrient rich and productive lakes are termed eutrophic and are considered as being in a higher trophic state. Nutrient poor lakes, low in productivity are termed oligotrophic and are defined as being in a lower trophic state. Mesotrophic lakes are typified by moderate levels of nutrients and productivity and fall between the eutrophic and oligotrophic classifications. Hypertrophic lakes are very productive and extremely rich in nutrients and are classified above the eutrophic category. The impairment of use potential is minimal for oligotrophic lakes in regard to most water use aspects, and highest for eutrophic and hypertrophic lakes, mesotrophic lakes occupy a intermediate position in this respect.

4.1.1 Phosphorous and Other Trophic Status Indicators

4.1.1.1 Phosphorous

A key measure of any aquatic environment and its trophic state is the quantity of total phosphorous (total organic plus inorganic phosphorous) in the system. Phosphorous is an essential plant nutrient and cycles rapidly in the aquatic environment. Phosphorous may be a limiting factor for plant growth. Lakes with higher levels of phosphorous usually are quite productive and generally indicate a higher trophic state. External sources of phosphorous may include: domestic sewage containing human excrement and phosphate from detergents and; runoff from agricultural lands. The Saskatchewan surface water quality objective for phosphorous (as P) is 0.05 mg/L (Saskatchewan Environment, 1983).

Table 3 provides a summary of mean total phosphorous (T.P.) values for the Kenosee Lake study. Mean total phosphorous values for all stations combined (Table 3) ranged from 0.05 mg/L during the August survey to 0.08 mg/L during the February survey. The slightly greater February mean T.P. values may have resulted from the release of phosphorous from decaying vegetation and bottom sediments during the winter months. The lower mean T.P. concentration noted for the August survey may have been a result of phosphorous being tied up by the abundant macrophyte growth during the summer season (see Section 4.4). Mean T.P. values generally exceeded the 0.05 mg/L objective however this is not unusual for naturally nutrient-enriched surface waters common to the prairie environment.

Mean ortho-phosphorous (Ortho-P) values are presented in Table 4. Mean Ortho-P values (Table 4) were generally quite consistant at about 0.05 mg/L through the study period. However, minimum and maximum data (Table 4) showed that the August survey exhibited the greatest range of single sample Ortho-P. concentrations (0.03 to 0.27 mg/L) while the February results showed the best variation (0.04 to 0.07 mg/L). A few high values may have masked the trend towards lower Ortho-P concentrations during open-water periods. Lower Ortho-P concentrations in the water column are generally expected during open-water periods due to increased uptake by plants, microbes and algae. Consistent spatial trends could not be identified for either total phosphorous or ortho phosphorous data.

TABLE 3

Mean Total Phosphorous Concentrations
(all values mg/L)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	0.04	0.07	0.06	0.07	0.06
2	0.06	0.09	0.08	0.06	0.07
3	0.04	0.06	0.08	0.06	0.06
4	0.05	0.07	0.07	0.05	0.06
5	0.05	0.13	0.12	0.09	0.09
6	0.07	0.08	0.07	0.08	0.07
7	0.04	0.07	0.08	0.10	0.07
8	0.03	0.07	0.06	0.05	0.05
9	0.04	0.05	0.08	0.07	0.06
10	0.04	0.05	0.07	0.14	0.08
11	0.04	0.05	0.08	0.07	0.06
12	0.11	0.06	0.05	0.07	0.08
13	0.04	0.15	0.13	0.06	0.08
14	0.04	0.06	0.06	0.07	0.06
All stations combined	0.05	0.07	0.08	0.07	0.07
Inst. min	0.01	0.03	0.05	0.02	0.01
Inst. max	0.54	0.17	0.34	0.75	0.75

TABLE 4

Mean Ortho Phosphorous Concentrations
(all values mg/L)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	0.09	0.04	0.05	0.05	0.06
2	0.03	0.04	0.05	0.06	0.05
3	0.05	0.04	0.05	0.05	0.05
4	0.04	0.05	0.05	0.05	0.05
5	0.03	0.10	0.05	0.08	0.07
6	0.09	0.03	0.06	0.05	0.06
7	0.03	0.05	0.05	0.06	0.05
8	0.03	0.04	0.06	0.05	0.04
9	0.04	0.04	0.05	0.07	0.05
10	0.03	0.03	0.06	0.05	0.04
11	0.03	0.03	0.05	0.06	0.04
12	0.11	0.04	0.05	0.06	0.07
13	0.04	0.09	0.06	0.05	0.06
14	0.03	0.04	0.05	0.08	0.05
All stations combined	0.05	0.05	0.05	0.06	0.05
Inst. min	0.03	0.03	0.04	0.04	0.03
Inst. max	0.27	0.25	0.07	0.12	0.27

4.1.1.2 Chlorophyll

Most aquatic plants contain chlorophyll "a" as their dominant photoreceptor. Chlorophyll may comprise from 4 to 12 percent of the ash-free dry weight of phytoplankton. Since chlorophyll is found in green plants including algae, it can be used to estimate plant biomass by assuming a relationship between the amount of chlorophyll pigment and cellular material (organic matter). Since chlorophyll is an estimate of the aquatic biomass, the chlorophyll concentration in water may generally be used as an indicator of the trophic status of a body of water. High chlorophyll concentrations generally indicate eutrophic waters. In instances where high chlorophyll concentrations occur algae growth may limit water use. Table 5 provides a summary of the chlorophyll "a" concentrations for the Kenosee Lake study. Mean chlorophyll "a" concentrations (Table 5) for all stations ranged from less than 2 mg/m^3 during the February survey to 12 mg/m^3 during the October survey. A maximum chlorophyll value of 33 mg/m^3

(Table 5) was recorded during the October survey. Elevated chlorophyll "a" concentrations during the fall survey may be attributable to the suspension of partially decomposed macrophytes since algae blooms were not observed throughout the study period. Spatial trends in chlorophyll concentration were not apparent in the study data.

4.1.1.3 Secchi Transparency

The classic procedure for determining water transparency has been to use the Secchi disk for measuring the depth to which it can be viewed. This depth is inversely proportional to the suspended particulate material that is primarily of biological origin. The deeper the disk is viewed, the clearer the water, thus small quantities of particulates of biological origin and consequently the general assumption of water of lower trophic state. Resuspended bottom sediments common to near-shore sampling sites also reduce water transparency.

TABLE 5

Mean Chlorophyll "a" Concentrations
(all values mg/m^3)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	3	10	<1	<1	4
2	4	12	3	3	6
3	3	7	<1	1	3
4	3	12	2	3	5
5	2	8	4	3	4
6	3	14	3	3	6
7	2	8	2	5	4
8	2	16	<1	4	6
9	3	13	<1	1	5
10	4	13	<1	1	5
11	3	11	<1	1	4
12	4	13	<1	1	5
13	3	22	6	2	8
14	3	9	<1	1	4
All stations combined	3	12	<2	2	5
Inst. min	<1	<1	<1	<1	<1
Inst. max	5	33	16	15	33

TABLE 6

Mean Secchi Transparency Depths
(all values in metres)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	>1.4	>2.0	NR	0.5	>1.3
2	>1.6	>2.8	NR	0.8	>1.7
3	>1.1	>1.0	NR	0.7	>0.9
4	>1.3	>1.5	NR	1.4	>1.4
5	>1.0	>1.0	NR	0.4	>0.8
6	>1.8	>1.0	NR	0.4	>1.2
7	>1.6	>1.0	NR	0.4	>1.1
8	3.7	2.5	NR	3.5	3.4
9	3.5	2.3	NR	4.0	3.5
10	2.4	3.3	NR	3.0	2.7
11	3.1	2.8	NR	2.9	3.0
12	2.9	NR	NR	>2.0	2.4
13	3.1	1.8	NR	4.0	3.0
14	3.0	2.3	NR	2.0	2.6
Stations 8 to 14 Inclusive	3.1	2.5		3.1	3.0

* February 1980 survey secchi depth measurements were not taken due to ice cover.

Mean secchi disk depths are presented in Table 6. Secchi transparency measurements at deep-lake stations were more representative of the actual water transparency since the lake bottom was often visible at the near-shore stations. The mean secchi depths for stations 8 through 14 were generally lowest during the October survey probably as a result of suspended decomposing plant material. The annual mean secchi depth for stations 8 through 14 (Table 6) was 3.0 m.

4.1.1.4 Trophic Status of Kenosee Lake

The predictions of the qualitative characteristics (trophic status) of Kenosee lake employed here follow methods established by Vollenweider and Kerekes (1980). The main components used in this classification are average annual lake phosphorous, average annual and peak chlorophyll concentrations and average yearly secchi disc transparency. Predictions were based on probability of classification since average conditions do not necessarily express the degree of variability and their qualitative nature.

The conditions limiting the applicability of the Vollenweider and Kerekes (1980) model to Canadian Lakes in general have been re-addressed by Janus and Vollenweider (1981). The factors most important to the Kenosee Lake study results are:

(a) Lakes having depths of less than 4 metres under which conditions it is likely that the littoral production zone (macrophytes, periphytic and benthic algae) dominate the lake metabolism reducing the relative importance of pelagic algae production.

Approximately 36% of Kenosee Lake was in depths of less than 4 metres and macrophyte growth was extensive in these areas. The relationship between the amount of chlorophyll pigment and cellular material is most applicable to the early stages of planktonic algae growth and is of less significance for estimating biomass when macrophytes are abundant.

(b) Lakes having very irregular flushing regimes, either seasonally or over consecutive years.

Outflows from Kenosee Lake have not been documented since 1954. The lake should be considered as somewhat of a nutrient sink and not in a complete state of dynamic equilibrium.

Subsequently, the following prediction of the trophic status of Kenosee Lake based on the model proposed by Vollenweider and Kerekes (1980) did require some special consideration during the interpretive process.

Figure 7 depicts the probability distribution for trophic categories based on mean annual total phosphorous concentration as proposed by Vollenweider and Kerekes (1980). The mean annual total phosphorous concentration (Table 3) of 0.07 mg/L (or 70 mg/m^3) applied to Vollenweider and Kerekes (1980) classification (Figure 7) shows that Kenosee Lake most likely

(63%) falls within the eutrophic category. This prediction of trophic status agrees with other qualitative characteristics and field observations.

Figures 8 and 9 depict the probability distribution for trophic categories proposed by Vollenweider and Kerekes (1980) for mean annual chlorophyll and maximum chlorophyll concentrations respectively. The mean annual chlorophyll "a" concentration of 5 mg/m^3 (Table 5) applied to this classification (Figure 8) indicates that Kenosee Lake most likely (62%) falls within the mesotrophic category. The maximum chlorophyll "a" concentration applied to the classification system (Figure 9) however, indicates that Kenosee Lake most likely (52%) falls within the Eutrophic category. The different trophic states predicted by the two chlorophyll classifications may be the results of the abundant macrophytes and/or the physical and chemical conditions which limit phytoplankton growth during the summer months (see section 4.1.3 and 4.4). Additionally the prediction of a lower

Figure 7 PROBABILITY DISTRIBUTION FOR TROPHIC CATEGORIES BASED ON MEAN ANNUAL TOTAL PHOSPHOROUS CONCENTRATION (VOLLENWEIDER AND KEREKES, 1980)

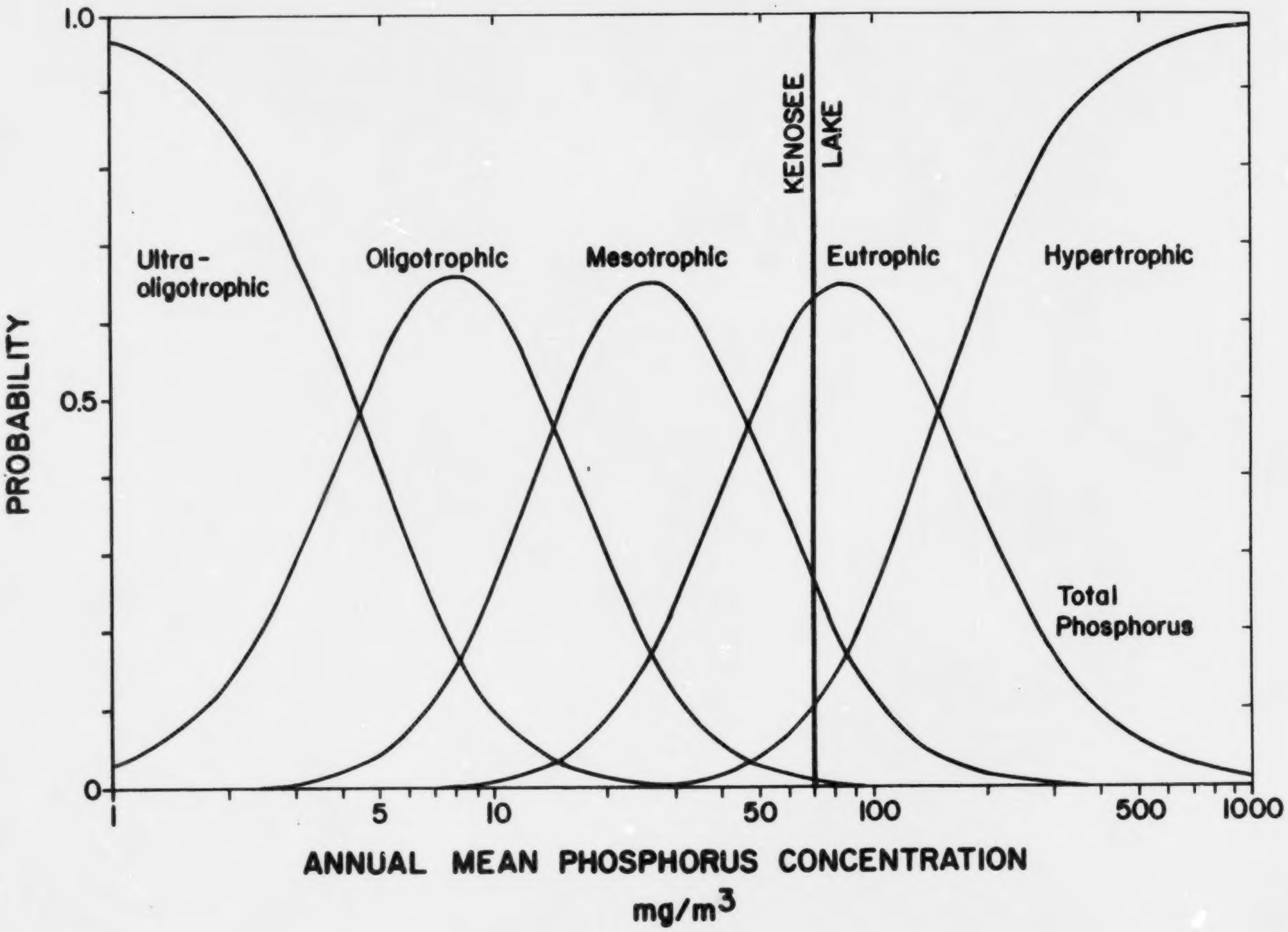


Figure 8 PROBABILITY DISTRIBUTION FOR TROPHIC CATEGORIES BASED ON MEAN ANNUAL CHLOROPHYLL CONCENTRATION
(VOLLENWEIDER AND KEREKES, 1980)

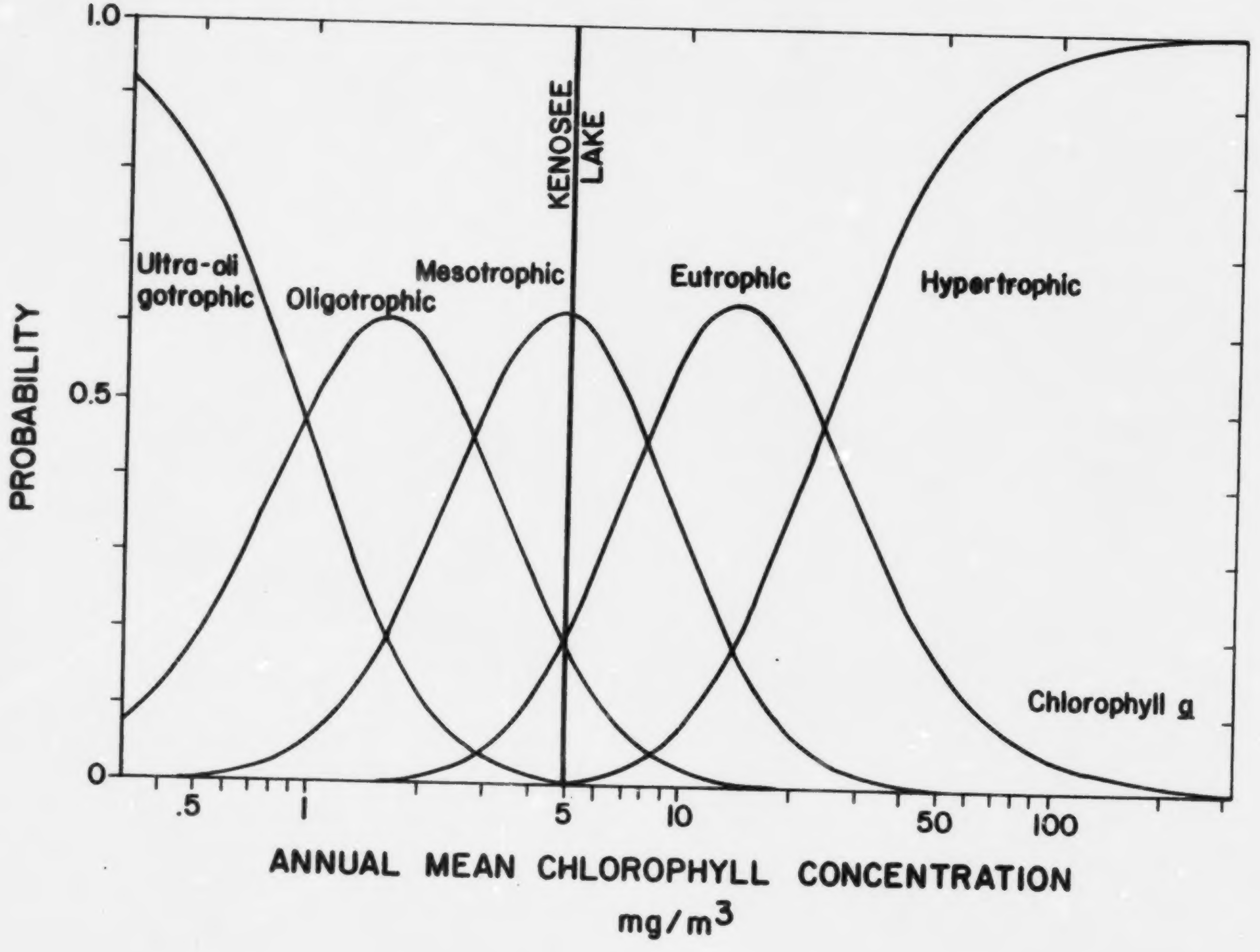
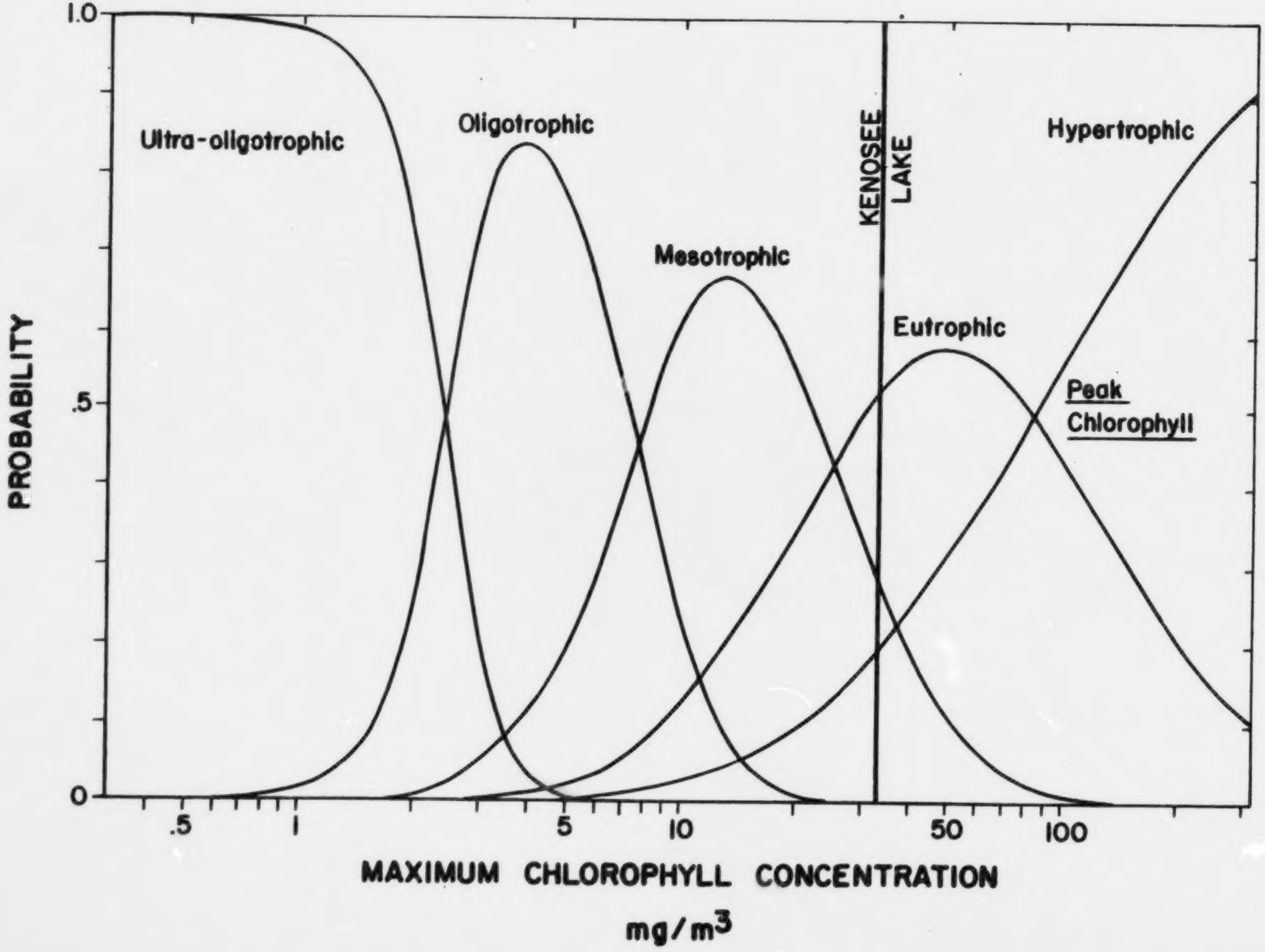


Figure 9 PROBABILITY DISTRIBUTION FOR TROPHIC CATEGORIES BASED ON MAXIMUM CHLOROPHYLL CONCENTRATION (VOLLENWEIDER AND KEREKES, 1980)



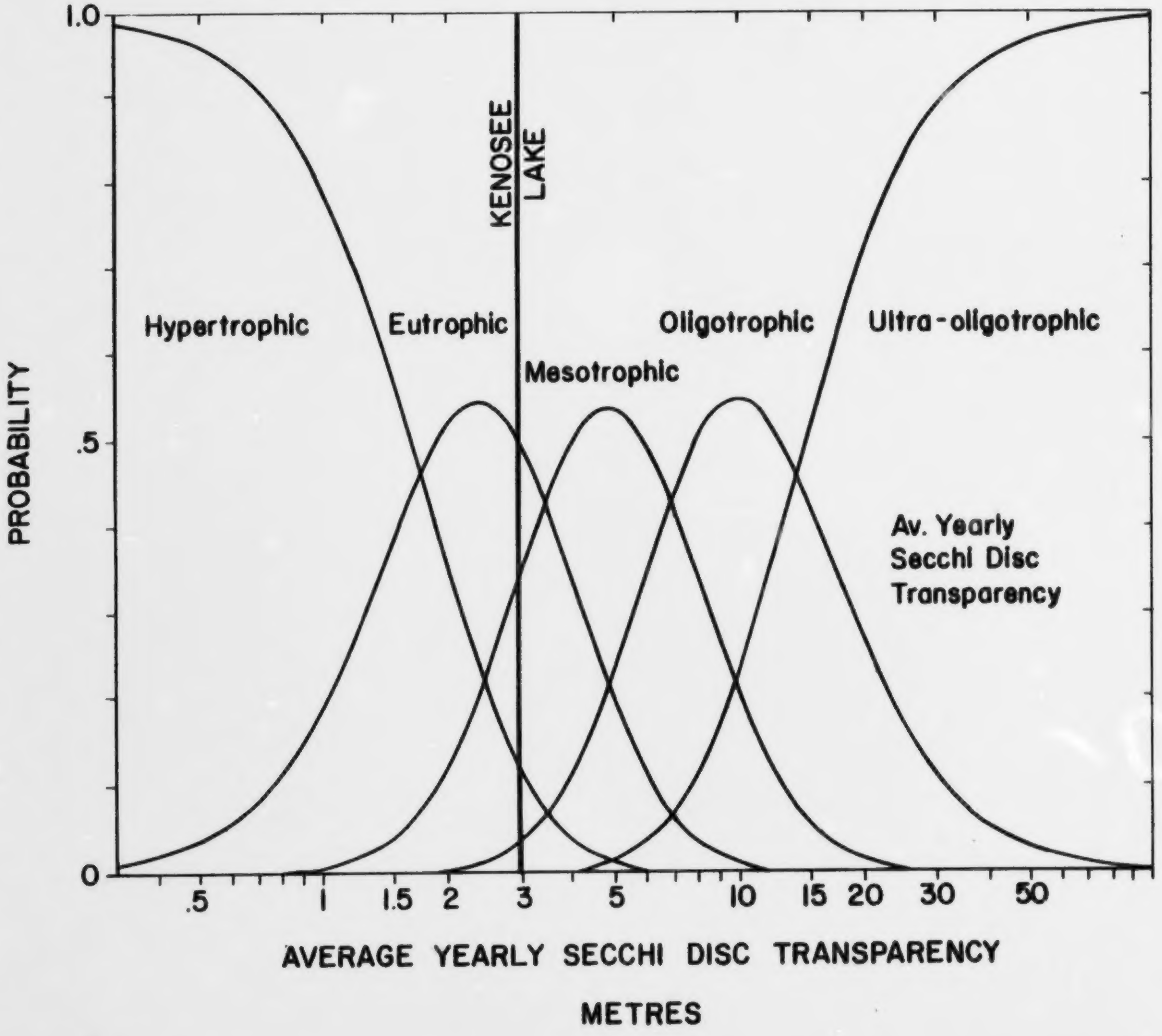
trophic state by this model using the chlorophyll data would be expected due to the predominance of macrophytic plant growth.

Figure 10 depicts the probability distribution for trophic categories for annual mean secchi disk transparency proposed by Vollenweider and Kerekes (1980). The average annual secchi depth value of 3.0 m applied to this classification (Figure 10) indicates that Kenosee Lake most likely (50%) falls within the eutrophic category.

4.1.2 Nitrogen

Nitrogen compounds are present in most plant and animal materials and thus in decaying organic matter. There are a number of important chemical forms in which nitrogen may occur. Organic nitrogen generally constitutes a relatively high proportion of the total nitrogen present. Total Kjeldahl nitrogen (TKN) which includes total organic nitrogen plus ammonia is frequently determined to measure the major quantity of nitrogen present in water. High levels of TKN in a water body may indicate the overall abundance of nutrients and therefore a higher trophic status.

Figure 10 PROBABILITY DISTRIBUTION FOR TROPHIC CATEGORIES BASED ON AVERAGE YEARLY SECCHI DISC TRANSPARENCY
(VOLLENWEIDER AND KEREKES, 1980)



Nitrogen is also usually present in inorganic forms of which nitrate and nitrite ions and ammonia and/or ammonium ions are the forms of most concern from the water quality standpoint. Inorganic forms of nitrogen promote growth of marophytes and algae in the aquatic environment.

Nitrogen sources in general may include: decaying plant and animal material; municipal and industrial waste discharge; runoff from fertile agricultural land; nitrogen fixing plants and bacteria; ground water infiltration; and rain or air borne deposition.

In Saskatchewan surface water quality objectives have been established for total nitrogen (total organic and inorganic) as 1.0 mg/L (Saskatchewan Environment, 1983). It is recognized, however, that many surface waters in southern Saskatchewan have naturally high levels of nutrients.

The results of total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N) and nitrate-nitrite nitrogen (NO_2 + NO_3-N) determinations appear as mean values in Tables 7, 8, and 9 respectively. Overall mean TKN values (Table 7) ranged from 1.5 mg/L during the August survey to 2.7 mg/L during the February survey. Overall mean NH_3-N concentrations (Table 9) ranged from less than 0.01 mg/L during the August survey to 0.34 mg/L during the February survey. Elevated NH_3-N concentrations during winter months were probably the result of: reduced activity by nitrifying bacteria which convert NH_3-N to NO_2 + NO_3-N; reduced NH_3-N uptake by bacteria and algae for nutrients requirements; and decreased loss of NH_3-N to the atmosphere. Organic nitrogen released from decaying plant and animal material and the coincident elevation in NH_3-N concentrations during ice cover periods probably account for the increase in winter TKN concentrations. Total nitrogen (TKN plus NO_2 + NO_3-N) values for Kenosee Lake generally exceeded the surface water quality objective of 1.0 mg/L, however, this is not uncommon for the nutrient rich surface waters of southern Saskatchewan lakes.

Mean overall NO_2 + NO_3-N concentrations (Table 9) ranged from less than 0.03 mg/L during the February survey to 0.08 mg/L during the October survey. Reduced bacterial nitrification during low water

TABLE 7

Mean Total Kjeldahl Nitrogen Concentrations
(all values in mg/L)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	1.5	1.8	2.6	1.8	1.8
2	1.7	2.2	2.5	1.9	1.9
3	1.6	1.7	2.6	1.8	1.8
4	1.5	1.9	2.6	1.8	1.8
5	1.5	1.7	3.3	1.8	1.9
6	1.6	1.8	2.6	1.8	1.8
7	1.5	1.7	2.7	2.0	1.9
8	1.5	2.1	2.7	1.7	1.8
9	1.5	1.9	2.8	1.8	1.8
10	1.5	1.7	2.5	1.8	2.0
11	1.5	1.8	2.7	1.9	1.8
12	1.5	1.1	2.6	1.8	1.7
13	1.5	2.1	3.3	1.8	2.1
14	1.5	1.7	2.6	1.9	1.9
All Stations Combined	1.5	1.8	2.7	1.8	1.9
Inst.Min.	1.3	0.1	2.3	1.7	0.1
Inst.Max.	2.5	2.7	5.0	2.6	5.0

TABLE 8

Mean Ammonia Nitrogen Concentrations
(all values in mg/L)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	0.010	0.053	0.300	0.020	0.087
2	<0.01	0.060	0.290	<0.01	0.090
3	0.010	0.033	0.320	0.017	0.088
4	<0.01	0.040	0.320	0.017	0.109
5	<0.01	0.100	0.343	0.017	0.118
6	<0.01	0.033	0.347	0.030	0.105
7	<0.01	0.037	0.343	0.022	0.114
8	<0.01	0.033	0.310	0.027	0.130
9	<0.01	0.037	0.350	0.023	0.105
10	<0.01	0.037	0.377	0.073	0.124
11	<0.01	0.037	0.323	0.073	0.103
12	<0.01	0.037	0.333	0.050	0.108
13	<0.01	0.017	0.403	0.083	0.178
14	<0.01	0.037	0.423	0.040	0.135
All Stations Combined	<0.01	0.043	0.341	0.049	0.035
Inst.Min.	<0.01	<0.01	0.28	<0.01	<0.01
Inst.Max.	0.01	0.21	0.60	0.15	0.60

TABLE 9

Mean Nitrate-Nitrite Nitrogen Concentrations
(all values in mg/L)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	<0.03	0.03	<0.03	0.03	0.03
2	<0.03	0.03	0.03	0.03	0.03
3	<0.03	0.03	<0.03	0.03	0.03
4	<0.03	0.06	<0.03	0.03	0.04
5	0.08	0.03	<0.03	0.03	0.04
6	0.08	0.03	<0.03	0.03	0.04
7	0.08	0.03	<0.03	0.03	0.04
8	0.08	0.03	<0.03	0.03	0.04
9	<0.03	0.03	<0.03	0.04	0.03
10	0.04	0.03	<0.03	0.03	0.03
11	<0.03	0.19	<0.03	0.08	0.08
12	<0.03	0.10	<0.03	0.08	0.06
13	0.03	0.03	<0.03	0.04	0.03
14	<0.03	0.52	<0.03	<0.08	0.15
All Stations Combined	0.03	0.08	<0.03	0.04	0.06
Inst.Min.	<0.03	<0.03	<0.03	<0.03	<0.03
Inst.Max.	0.17	1.4	0.03	0.17	1.4

temperature periods accounts for the below detection level $NO_2 + NO_3$-N values recorded for the February survey. A few anomalous values encountered during the October survey may account for the higher mean $NO_2 + NO_3$-N concentrations. Consistent spatial trends could not be identified in TKN, NH_3-N or $NO_2 + NO_3$-N data.

High levels of ammonia nitrogen are of concern since they add to the oxygen demand and are toxic to aquatic organisms. The toxicity of aqueous ammonia solutions is primarily attributable to unionized ammonia. The proportion of ammonia nitrogen present in water as unionized ammonia is usually very small and is influenced mostly by water temperature, pH and total dissolved solids. Under the winter temperature and pH conditions recorded for Kenosee Lake in February, 1980, maximum unionized ammonia nitrogen levels were considerably less (approximately one-quarter) than the maximum allowable level for individual samples suggested in the USEPA (1983) criteria for the protection of aquatic life.

4.1.3 Phytoplankton

Early recognition of differences in phytoplankton populations in lakes contributed to the origin of the trophic system of lake classification (Rawson, 1956). Eutrophic lakes generally display heavy phytoplankton growth when compared with the thin or poor phytoplankton growth of oligotrophic lakes. Additionally, the variety of phytoplankton species may differ in oligotrophic and eutrophic lakes. The presence of certain species of phytoplankton have also been used as indicators of the trophic character of lakes.

The phytoplankton surveys performed during the Kenosee Lake study were conducted primarily to provide a historical data base for future reference purposes. The phytoplankton sampling program was not designed to categorize the trophic status of Kenosee Lake, however, a limited interpretation of the data on that basis was performed. A complete summary of all algae identification and enumeration results compiled from the Kenosee Lake study are available from the BIODAT computerized file records.

When considering the results of phytoplankton analysis, counts which show the numerical percentage or dominance of different species in terms of total cells may be somewhat misleading since the cell size of different algae varies greatly. Thus it is necessary to consider both the quantitative and volumetric dominance of any particular species in the sample population.

The findings of relative seasonal quantitative and volumetric dominance determinations for individual species were tabulated according to species and phyla and are attached as Appendix B. A review of Appendix B exemplifies the differences which may exist between relative volumetric and quantitative dominance values for a single phytoplankton species. For example, during the May, 1980 survey the blue-green algae species Aphanothece clathrata constituted 87 per cent (Table B-3) of the volume of cells counted but only 1 per cent of the total quantity (total number of cells present).

Total relative quantitative and volumetric dominance figures for the five taxonomic phyla appear as in Table 10. An examination of Table 10 reveals that the dominant phytoplankton phyla varied from season to season. The Cyanophytes (blue-green algae) were dominant on both quantitative (83 per cent) and

TABLE 10

Summary of Total Relative (Per Cent) Quantitative and Volumetric Dominance According to Taxonomic Phyla

Taxonomic Phylum	August 22-24/79		February 18-20/80		May 26-28/80	
	% by Number	% by Volume	% by Number	% by Volume	% by Number	% by Volume
Chlorophyta	9	<1	<1	4	14	3
Chrysophyta	3	1	18	33	38	3
Cyanophyta	83	99	1	1	1	89
Pyrrhophyta	4	<1	81	62	47	5
Euglenophyta	NF	NF	<1	<1	NF	NF

NF - Not Found
< - less than

volumetric (99 per cent) criteria during the August survey. During the February survey the Pyrrhophytes (dinoflagellates) were dominant quantitativety (81 per cent) and volumetrically (62 per cent).

Table 11 provides a summary of the mean densities of phytoplankton cells and colonies based on taxonomic phyla. Phytoplankton densities (Table 11) were highest during the August survey (2.9 x 10^6 cells/L) and lowest during the February survey (7.3 x 10^5 cells/L).

TABLE 11

Summary of Pooled Mean Phytoplankton Cell and Colony Densities

Taxonomic Phylum	August 22-24/79	February 18-20/80	May 26-28/80
	No. cells/L	No. cells/L	No. cells/L
Chlorophyta	2.5 x 10_5	2.0 x 10^3	1.1 x 10^5
Chrysophyta	9.8 x 10^4	1.3 x 10^5	2.9 x 10^5
Cyanophyta	2.4 x 10^6	4.0 x 10^3	5.7 x 10^3
Pyrrhophyta	1.2 x 10^5	5.9 x 10^5	3.7 x 10^5
Euglenophyta	0	7.3 x 10^1	0
Total of All Phyla	2.9 x 10^6	7.3 x 10^5	7.8 x 10^5

Table 12 summarizes the total number of species for each of five taxonomic phyla which were identified from each survey. The August survey samples (Table 12) showed the greatest number of species (39) whereas the February survey showed the least (23) number of species.

Phytoplankton species usually indicative of hypertrophic conditions in prairie lakes such as *Aphanazonamon flos-aquae*, *Microcystis flos-aquae* and *Anabaena* species were not found to occur at dominant levels during any of the seasonal surveys.

TABLE 12

Summary of Phytoplankton Species Occurrence

Taxonomic Phyla	August 22-24/79	February 18-20/80	May 26-28/80
	No. of Species	No. of Species	No. of Species
Chlorophyta	15	9	12
Chrysophyta	8	8	7
Cyanophyta	14	3	6
Pyrrhophyta	2	2	3
Euglenophyta	0	1	0
Total	39	23	28

Other species of blue-green algae (Cyanophyta) however, were dominant during the August survey. The pattern of occurrence of blue-green algae species suggests that Kenosee Lake falls within the eutrophic category. Other physical or chemical conditions and or the abundance of macrophytes in Kenosee Lake may be functioning to limit the growth of algae species (i.e. Aphanazonamon sp., Microcystis sp., and Anabaena sp.) typically present in eutrophic prairie waters.

4.2 Bacteriological Evaluation

All recreational waters should be sufficiently free of pathogenic bacteria so as not to pose health hazards through infections (U.S. EPA 1972). Correlations have been demonstrated (Smith et al, 1951) (Smith and Woolsey 1952) between incidence of illness and bathing waters of a particular bacteria quality. The presence of fecal pollution in natural waters indicate that bacterial, viral or protozoan enteric pathogens may be present at any time.

The bacteriological water quality of Kenosee Lake is of greatest importance for its recreational use aspect since no licensed water users for consumption after treatment are known to exist. Golf course watering and a fish rearing project constitute the only licensed water users at Kenosee Lake. Therefore, the bacteriological water quality data obtained during the survey has been interpreted in terms of the provincial surface water quality objectives concerning direct contact recreation.

In Saskatchewan the bacteriological quality of surface water is assessed using various objectives for indicator bacteria (Total and Fecal Coliforms). The bacteriological surface water quality objectives concerning direct contact recreation are as follows:

In waters used for direct contact recreation or vegetable crop irrigation, the geometric mean of not less than five samples taken over not more than a 30-day period should not exceed 1000 per 100 mL total coliforms, nor 200 per 100 mL fecal coliforms, nor exceed these numbers in more than 20% of the samples examined during any month, nor exceed 2400 per 100 mL total coliforms on any day.

The geometric mean figures used in the following interpretation of bacteriological data, were calculated using the next lowest whole number for less than quantities and the next greatest whole number for greater than quantities. For values less than one a value of 0.9 was used for the calculation of geometric means.

4.2.1 Coliform Bacteria

Coliform bacteria have long been accepted (U.S. EPA 1972) as the primary indicators of fecal contamination although a quantitative relationship between coliform and enteric pathogens does not exist (Dutka, 1973). The use of fecal coliform bacteria has greater sanitary significance than the use of total coliform bacteria because fecal coliforms, like enteric pathogens, are restricted to the intestinal tract of warm blooded animals (Geldreich, 1966).

Table 13 provides a listing of the geometric mean total coliform densities for the Kenosee Lake study. Mean values (Table 13) ranged from 4 orgs/100 ml during the May survey to 349 orgs/100 ml during the August survey. Seasonal geometric mean values for all stations combined (Table 13) ranged from less than 10 orgs/100 ml for the February survey to 130 orgs/100 ml for the August survey. Only two of the 313 analysis performed for total coliforms exceeded the 2400 orgs/100 ml for individual samples. All seasonal geometric mean total coliform values (Table 13) were within the surface water quality objective value of 1000 orgs/100 ml related to contact recreation.

Table 14 provides a summary of the geometric mean fecal coliform densities for the Kenosee Lake study. The geometric fecal coliform values (Table 14) were generally below a level of 10 orgs/100 ml. All geometric mean fecal coliform values recorded for the Kenosee Lake study were within the provincial objective of 200 orgs/100 ml.

Diurnal or spatial trends were not apparent in the study data for either total coliform or fecal coliform bacteria. It should be noted that bathing activity was only seldom noticed during the field surveys.

TABLE 13

Geometric Mean Total Coliform Densities
(all values - organisms/100 ml)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	52	85	<10	25	32
2	97	<20	<10	8	24
3	57	<20	<10	10	22
4	88	36	<10	19	43
5	106	20	<10	27	40
6	170	<20	<10	8	33
7	45	<20	<10	29	35
8	170	82	<10	9	37
9	136	25	<10	8	27
10	<100	28	<10	5	21
11	118	<20	<10	9	27
12	214	24	<10	7	27
13	349	53	<10	7	37
14	136	31	12	4	21
All Stations Combined	130	30	<10	10	27
Inst.Min.	<20	<20	<10	<1	<1
Inst.Max.	3600	400	20	>1000	3600

TABLE 14

Geometric Mean Fecal Coliform Densities
(all values - organisms/100 ml)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	<10	<1	<10	1	2
2	<10	<1	<10	2	3
3	<10	<1	<10	1	3
4	<10	<1	<10	1	3
5	<10	<1	<10	1	3
6	<10	<1	<10	2	3
7	<10	<1	<10	5	5
8	<10	<1	<10	3	4
9	<10	<1	<10	<1	3
10	<10	<1	<10	<1	3
11	<10	<1	<10	3	4
12	12	2	<10	<1	4
13	<10	<1	<10	<1	3
14	<10	<1	<10	<1	3
All Stations Combined	<10	<1	<10	1	3
Inst.Min.	<10	<1	<10	<1	<1
Inst.Max.	20	2	<10	53	53

Based on the results of the analysis for coliform bacteria and the provincial water quality objectives the waters of Kenosee Lake were bacteriologically satisfactory for direct contact recreational purposes.

4.2.2 Fecal Streptococci

Fecal streptococci bacteria are valuable pollution indicators in the study of lakes and other surface waters. In combination with fecal coliform data, fecal streptococci results may provide more information about pollution sources, i.e. domestic vs agricultural and/or wildlife, because certain fecal streptococci are host specific.

Table 15 summarizes the geometric mean fecal streptococci densities for the Kenosee Lake study. Positive geometric mean fecal streptococci values (Table 15) ranged from 1 org/100 ml to 13 orgs/100 mls. Generally all fecal streptococci values were quite low and, as with coliforms, spatial variations in the data were not present.

The prevalence of low levels of fecal streptococci indicates that little or no pollution from agricultural and/or wildlife sources was evident during the Kenosee Lake study.

TABLE 15

Geometric Mean Fecal Streptococci Densities
(all values - organisms/100 ml)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	<10	x	1	4	4
2	<10	x	<1	1	3
3	<10	x	<1	2	3
4	<10	x	2	2	3
5	<10	x	3	2	4
6	<10	x	<1	5	4
7	<10	x	1	13	5
8	<10	x	2	2	3
9	<10	x	1	<1	2
10	<10	x	<1	<1	2
11	<10	x	<1	<1	2
12	<10	x	3	1	3
13	<10	x	<1	<1	2
14	<10	x	2	1	3
All Stations Combined	<10	x	1	2	3
Inst.Min.	<10	x	<1	<1	<1
Inst.Max.	10	x	9	>100	>100

x Analysis not performed for fecal streptococci during October survey due to laboratory mishap.

4.3 Chemical Evaluation

4.3.1 Physical Parameters and Organic Variables

4.3.1.1 Dissolved Oxygen and Temperature

The concentration of dissolved oxygen (DO) in any surface water body is subject to seasonal and diurnal fluctuations. In lakes, changes in dissolved oxygen concentration are primarily due to variations in temperature, photosynthetic activity, surface aeration, and by loading of organic materials. The solubility of atmospheric oxygen is inversely proportional to altitude and water temperature. Photosynthesis and wave action function to re-oxygenate surface water. The decomposition of natural or introduced organic materials and the respiration by plants and microorganisms utilize oxygen. During winter months ice cover prevents the re-oxygenation of surface waters. Additionally, snow cover reduces the light penetration and photosynthetic production of oxygen within the lake.

Individual dissolved oxygen values provide information about the absolute quantity of this gas dissolved in water but do not give information about the degree of saturation of the water at the temperature occurring when the sample is obtained. For instance, an open water may contain an adequate quantity of dissolved oxygen for fish survival (e.g. 5 mg/L) but if this quantity present is less than accounted for by the solubility of oxygen at the recorded water temperature, there is an indication that some substance or process is utilizing oxygen at a rate exceeding its diffusion from the atmosphere or from photosynthesizing aquatic plants and algae. Such substances may be introduced to a lake through effluent discharges or may occur due to naturally occurring high levels of labile organic matter or respiring plants and microorganisms.

In all lakes diurnal fluctuations of oxygen content are commonly observed. During periods of darkness, when photosynthetic contributions of oxygen to the water ends, plant respiration and microbial activity may utilize dissolved oxygen at a rate faster than diffusion from the atmosphere can replace it. Under such conditions oxygen concentrations below expected saturation levels are encountered in lakes. Reductions in dissolved oxygen content to levels below saturation may be observed in lakes during daylight hours in areas directly influenced by high loads of organic material and nutrients associated with wastewater effluent discharges. If excessive quantities of oxygen consuming materials are present the level of dissolved oxygen in a lake may fall below that required for the survival of fish or other aquatic animals. In Saskatchewan the surface water quality objective for dissolved oxygen has been established at 5 mg/L (Saskatchewan Environment, 1983) to protect this most sensitive use of surface waters.

A listing of dissolved oxygen, temperature and per cent saturation values recorded during the Kenosee Lake study is presented in Appendix C. The data presented in Table 16 provides mean values for a combination of all recordings according to depth for each survey. Instantaneous minimum and maximum values appear in Table 17.

A review of Tables 16 and 17 reveals that DO concentrations remained above the surface water quality objective during the August and October surveys. Instantaneous saturation values ranged from 57 per cent to 134 per cent for the August survey and 68 per cent to 103 per cent during the October survey (Table 17). Mean values (Table 16) for both DO and saturation were satisfactory during the August and October surveys.

During the February survey the mean DO concentrations reported for depths greater than 2.0 m (Table 16) were less than 5 mg/L. Additionally 69, or 48 per cent, of the instantaneous DO recordings during the winter survey were less than 5.0 mg/L

TABLE 16

Mean Dissolved Oxygen, Temperature and Per Cent
Saturation Values Across Depth Profiles for Kenosee Lake

	August, 1979			October, 1979			February*,1979			May, 1980		
Depth	DO	T°C	% Sat.	DO	T°C	% Sat.	DO	T°C	% Sat.	DO	T°C	% Sat.
Surface	9.7	15.6	105	10.4	3.9	86	6.4	0.1	48	6.8	18.5	79
1.0 m	8.8	15.6	95	10.3	3.9	85	5.8	0.2	44	6.7	18.5	78
2.0 m	8.3	15.8	91	10.2	4.3	86	5.0	0.5	38	6.5	18.2	75
3.0 m	8.2	15.8	90	10.3	4.2	86	4.3	0.8	33	6.5	18.2	75
4.0 m	8.1	15.8	89	10.0	4.2	84	3.9	1.0	30	6.5	18.1	75
5.0 m	8.0	16.2	89	10.0	4.5	84	2.6	1.3	20	6.5	18.2	75
6.0 m	7.8	16.3	87	9.8	4.5	82	0.9	2.2	7	6.0	18.0	69
7.0 m	8.2	16.3	91	-	-	-	-	-	-	6.8	17.5	77

* - Figures given reflect distance below the bottom of the ice layer.

TABLE 17

Minimum and Maximum Instantaneous Dissolved Oxygen,
Temperature and Per Cent Saturation Values

	August, 1979			October, 1979			February*,1979			May, 1980		
	DO	T°C	% Sat.	DO	T°C	% Sat.	DO	T°C	% Sat.	DO	T°C	% Sat.
Instantaneous Minimum	5.3	14.0	57	8.6	1.8	68	0.5	0	4	2.5	16.0	29
Instantaneous Maximum	12.1	18.0	134	12.5	5.5	103	9.6	2.5	72	9.3	21.0	110

(Appendix C). Instantaneous per cent saturation values for the February survey (Table 17) ranged from 4 per cent to 72 per cent. These results indicate that a reduction in the dissolved oxygen concentration occurred during the ice cover period. The potential for winter fish kills in parts of the lake due to oxygen depletion is indicated by these results. Further study of dissolved oxygen conditions during the late winter period would provide valuable information for assessing the likelihood of fish kills due to oxygen depletion.

Mean dissolved oxygen concentrations (Table 16) for the May survey were all above the 5.0 mg/L objective. However, 68, or 18 per cent, of the instantaneous DO recordings (Appendix C) were below the objective. Instantaneous per cent saturation values ranged from 29 per cent to 110 per cent for the May survey. Most of the lower DO values for the May survey (Appendix C) were recorded during night hours and were followed by a rapid re-oxygenation shortly after sunrise. These results indicate that a potential did exist for a night-time oxygen depletion in shallow areas during the May survey.

Diurnal dissolved oxygen and temperature measurements were completed for one-day periods at four hour intervals during the August and May surveys. The minimum DO concentrations generally occurred between 09:30 and 11:30 hours during the August survey and between 01:20 and 02:45 hours during the May survey (Appendix C). The differences in daylight hours and photosynthetic activity for the two surveys appears to account for the observed variation in DO minima. Rapid re-oxygenation after sunrise suggests that significant photosynthetic activity occurred during daylight hours during the May survey.

The absence of dissolved oxygen and temperature stratification combined with other chemical data suggests that Kenosee Lake remains well mixed throughout the year.

4.3.1.2 Total Organic Carbon

Most of the organic carbon in water is composed of humic substances and partly degraded plant and animal materials. Photosynthetic activities contribute dissolved organic carbon to aquatic systems and the amounts of organic components varies with the growth cycles of vegetation. Runoff from forested and agricultural lands and municipal waste discharges may further increase the levels of total organic carbon (TOC) in water. The decomposition of organic carbon can lower dissolved oxygen to levels below that required by aquatic organisms. Additionally the decomposition of total organic carbon is related to biochemical oxygen demand of surface waters.

Generally, spring and summer TOC concentrations for Kenosee Lake approached the upper limit of the environmental range of 1 to 30 mg/L for natural surface waters (McNeely, Neimanis and Dwyer, 1979). The abundant growth of macrophytic plants probably accounts for the TOC concentrations encountered during these periods.

Mean, minimum and maximum TOC values are presented in Table 18. Mean TOC concentrations for the August (31 mg/L) and May (37 mg/L) surveys were approximately twice the mean value (14 mg/L) for the October survey (Table 18). The lower mean TOC value for the October survey may be the result of: reduced contributions from phytoplankton and macrophytes; reduced surface runoff; and more TOC being tied up in plant growth during the fall season prior to the onset of vegetative degradation. Significant spatial trends in TOC data were not apparent.

4.3.1.3 Biochemical Oxygen Demand

The biochemical oxygen demand (BOD) of a water is the amount of oxygen required to oxidize the organic matter by aerobic microbial decomposition to a stable inorganic form. Therefore BOD is not a pollutant itself, but it is a measure of organic pollution. The surface water quality objectives (Saskatchewan Environment, 1983) state that the BOD must not exceed a limit which would create a dissolved oxygen content of less than 5 mg/L.

TABLE 18

Mean Total Organic Carbon Concentrations
(all values mg/L)

Station	August 13-15/79	October 22-24/79	February* 18-20/80	May 26-28/80	All Surveys Combined
1	35	16	-	39	30
2	26	14	-	38	25
3	24	16	-	38	26
4	25	17	-	37	25
5	26	15	-	37	26
6	29	16	-	38	28
7	28	14	-	39	29
8	33	12	-	36	27
9	33	15	-	35	28
10	32	14	-	34	28
11	31	15	-	39	29
12	34	10	-	37	27
13	34	17	-	39	30
14	37	12	-	33	27
All Stations Combined	31	14	-	37	27
Inst.Min.	20	4	-	22	4
Inst.Max.	47	22	-	42	47

* Total organic carbon values for the February survey could not be obtained due to the failure of laboratory instrumentation.

A summary of the mean, minimum and maximum BOD concentrations is presented in Table 19. Minimum and maximum BOD levels ranged from 0.4 to 7.5 mg/L (Table 19). The trend towards slightly higher mean BOD levels for the October survey may have resulted from reductions in the photsynthetic activity of macrophytic plants in the shallow areas, however, this trend was not overly pronounced.

A slight variation in BOD levels (Table 19) was apparent for the August survey when the mean values were lower (1.2 to 1.4 mg/L) at the shallow lake stations than at the deeper mid-lake stations (1.7 to 2.7 mg/L). Macrophyte growth in shallow areas (see Section 4.4) functioning to increase the average dissolved oxygen concentrations may partially account for the lower BOD levels observed at these stations during the August survey.

TABLE 19

Mean Biochemical Oxygen Demand
(all values mg/L)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	1.2	2.2	1.6	1.2	1.4
2	1.4	2.7	1.3	1.1	1.5
3	1.2	2.2	1.9	1.2	1.4
4	1.2	2.6	2.0	1.1	1.5
5	1.4	2.1	4.6	1.2	1.9
6	1.4	2.8	2.2	1.2	1.6
7	1.2	1.9	2.0	1.2	1.4
8	1.7	2.8	1.6	1.0	1.6
9	1.9	2.4	1.8	1.1	1.7
10	2.3	2.0	2.3	1.0	1.8
11	2.3	2.2	1.8	1.0	1.8
12	2.7	2.1	1.7	0.9	1.8
13	1.8	3.7	2.8	1.0	1.9
14	2.6	2.1	1.5	1.0	1.8
All Stations Combined	1.7	2.4	2.1	1.1	1.6
Inst.Min.	0.4	1.6	0.8	0.4	0.4
Inst.Max.	7.5	4.8	7.0	2.6	7.5

4.3.2 Suspended Solids

Suspended solids may enter lake water from several sources including: erosion of the surrounding shoreline, agricultural and construction areas during periods of high runoff; decay of organic matter within the lake or the surrounding drainage basin; wind erosion of surrounding agricultural soils; and man-made effluent discharges. Additionally bottom sediments are readily resuspended by wave action in shallow areas.

Suspended solid concentrations in surface waters are important because of their effects on light penetration, temperature, solubility products, and aquatic life. Because suspended particles inhibit the penetration of sunlight, waters warm more rapidly at the surface during turbid periods and thus may potentially affect oxygen transfer from the air and inhibit vertical mixing. Fish gills may be clogged by suspended solids which impairs their proper functions of respiration and excretion. Blanketing of plants and sessile animals with sediments as well as the blanketing of important habitats, such as spawning sites, can cause drastic changes in the aquatic ecosystem. Pesticides and heavy metals may be absorbed on suspended particles and strongly held with them. Increased levels of suspended solids reduces the aesthetic appeal of the lake waters for various recreational uses.

Table 20 provides a summary of the seasonal total suspended solid values calculated from the Kenosee Lake study data. Seasonal mean total suspended solid values for all stations combined (Table 20) reached a maximum during the May survey (20 mg/L) and a minimum during the August survey (5 mg/L). The combined mean TSS value (Table 20) for the February survey (13 mg/L) was biased by two elevated values.

The mean total suspended solid values for individual stations (Table 20) generally were higher at shallow stations. Spatial variations in TSS concentrations probably result from shoreline erosion and the resuspension of bottom sediments by wave action at the near shore monitoring sites.

Total suspended solid concentrations reported for Kenosee Lake generally met the US EPA (1972) guideline (25 mg/L maximum) for a high level of protection of an aquatic community.

TABLE 20

Mean Total Suspended Solid Concentrations
(all values mg/L)

	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	10	4	2	23	10
2	5	20	4	8	10
3	6	5	5	6	6
4	6	5	6	7	6
5	7	11	80	26	31
6	4	12	4	25	11
7	9	5	4	77	30
8	4	5	2	5	4
9	4	4	4	6	5
10	4	4	3	6	4
11	4	4	6	9	5
12	4	5	3	11	6
13	4	21	69	5	25
14	3	7	3	19	8
All Stations Combined	5	8	13	20	12
Inst.Min.	3	2	1	3	1
Inst.Max.	21	52	229	256	256

Volatile suspended solids is partially a measure of the organic fraction of the total suspended solids. Volatile suspended solids may arise from living or decaying plant and animal material and the introduction of wastes rich in organic matter. Volatile suspended solids in high concentrations may burden natural purification processes and may also be objectionable from an aesthetic viewpoint.

Table 21 provides a summary of the mean VSS concentrations for the Kenosee Lake study data. Temporal variations in the mean seasonal VSS values closely resemble those for TSS. The mean VSS values (Table 21) were highest (5 mg/L) during the May survey and lowest during the August survey (2 mg/L). The combined mean VSS values for the winter survey would generally be expected to be the lowest for the entire survey, however, the February mean VSS concentration of 3 mg/L (Table 21) was biased by two elevated values.

Slightly elevated VSS concentrations at near shore sites are probably a result of wave action in shallow areas where sediments and the growth of macrophytic plants provide a source of the particulate matter.

TABLE 21

Mean Volatile Suspended Solid Concentrations
(all values mg/L)

Station	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	3	2	1	6	3
2	2	6	2	3	4
3	2	2	2	4	2
4	2	1	2	3	2
5	2	4	16	7	7
6	1	4	2	5	3
7	4	2	2	14	6
8	2	2	1	3	2
9	2	1	2	3	2
10	2	2	1	3	2
11	1	2	2	2	2
12	1	2	1	2	2
13	1	5	12	2	5
14	1	2	1	6	3
All Stations Combined	2	3	3	5	3
Inst.Min.	<1	<1	<1	1	<1
Inst.Max.	10	11	41	40	41

Specific water quality objectives for VSS have not been established, however, all mean values fall within the US EPA (1972) guideline (25 mg/L maximum) for a high level of protection for aquatic communities. Suspended solids did not reach concentrations which would impair water clarity for swimming and diving uses.

4.3.3 Inorganic Variables

4.3.3.1 pH

pH indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution. The pH of the water may influence the species composition of an aquatic environment and affect the availablity of nutrients and the relative toxicity of many trace elements. A pH value above nine may lower the solubility of calcium carbonate, causing a precipitate and thus a milky appearance which may impair the aesthetic value and recreational use of the water. Excessive pH values may limit the natural reproduction of many fish species. A summary of the mean pH values for the Kenosee Lake study are presented in Appendix D, Table D-1.

Mean pH values for the February survey were approximately 8.6, 0.2 pH units lower than those values for open water surveys (Table D-1). Ice cover and lower water temperatures during winter months combine to retain greater concentrations of carbon dioxide and therefore carbonic acid, which would lower the pH of the water. Additionally acidity associated with decomposition by-products during winter months may also serve to lower the pH of the lake water. The slightly higher pH levels of 8.8 during open water months (Table D-1) may be caused by surface aeration and photosynthesis with the associated reduction in carbon dioxide content.

The pH values for Kenosee Lake generally exceeded the provincial surface water quality objective range (Saskatchewan Environment, 1983) of 6.5 to 8.5 units, however, the recorded values are comparable to other lakes with limited drainage in the immediate area.

4.3.3.2 Conductivity

Conductivity is a numerical expression of a water's ability to conduct an electrical current. Conductivity provides a rapid estimate of the total dissolved solid concentration of water. High total dissolved solid concentrations indicated by elevated conductivity values may limit the suitability of water as a drinking or irrigational source. A summary of the mean conductivity values is presented in Appendix D, Table D-2.

Mean conductivity values (Table D-2) were highest (approximately 2200 us/cm) during the February survey. Concentration of dissolved solids by ice formation probably accounts for the higher winter conductivity values for Kenosee Lake. A slight spatial trend towards higher mean conductivity values at the deeper mid-lake stations was apparent for the August and February surveys.

Although water quality objectives for conductivity have not been established, Kenosee Lake would be considered as slightly saline according to a classification of total dissolved solids and salinity relationships by McNeely, Nemanis and Dwyer (1979). The conductivity values recorded for Kenosee Lake are probably a result of the accumulation of dissolved solids over time by evaporation, ground water inflows, low water levels and minimal outflows from the lake basin.

4.3.3.3 Chlorides

Chlorides are significant in surface waters since in excessive concentrations they may impart a taste to water supplies; limit the irrigational use; and cause a shift in the biotic community. No known man-made sources of chlorides exist within the Kenosee Lake area.

Appendix D, Table D-3 provides a listing of the seasonal mean chloride concentrations for the Kenosee Lake study. An examination of Table D-3 reveals that chloride concentrations exhibited a slight seasonal variation. Seasonal mean chloride concentrations reach minimum levels (14 mg/L) during the May survey probably as a result of dilution by surface runoff which was generally less than expected prior to and during the study period (Table D-3). Maximum seasonal mean chloride concentrations (19 mg/L) occurred during the February survey probably as a combined result of concentration by evaporation over the summer and fall months and by the formation of ice cover and the increased significance of ground water inputs during winter months (Table D-3).

The lack of discernable spatial trends in the chloride data indicates that pollution from domestic sewage was insignificant or not detected by the sampling program. The overall mean chloride concentration of 16 mg/L is slightly higher than the 10 mg/L value recorded for 1960 by Royer (1962) and probably is a result of low water levels and infrequent outflows.

4.3.3.4 Iron

In water, iron can discolour clothes and plumbing fixtures and can cause scaling which encrusts pipes. Excessive concentrations may promote bacterial activity in pipes and service mains.

Appendix D, Table D-4 provides a listing of the mean iron concentration for the Kenosee Lake study. Mean iron concentrations (Table D-4) were generally lowest (0.1 mg/L) during the August survey. Spatial trends in iron concentrations within the lake were not apparent. Kenosee Lake mean iron concentrations ranged from 0.1 mg/L to 0.3 mg/L and generally equalled or were within the Saskatchewan surface water quality objective (Saskatchewan Environment, 1983) of 0.3 mg/L.

4.3.3.5 Manganese

The presence of substantial amounts of manganese is objectionable in laundry processing because of its staining qualities. Manganese may form deposits on cooking utensils and in plumbing pipes but is of no significance to recreational use.

Appendix D, Table D-5 provides a summary of the mean manganese concentration for the Kenosee Lake study. Temporal and spatial trends in manganese concentration were not apparent in the study data. Mean manganese values ranged from 0.01 mg/L to 0.03 mg/L for the Kenosee Lake study data (Table D-5). Mean manganese concentrations were generally within the provincial surface water quality objective (1983) of 0.05 mg/L.

4.4 Macrophytes

The term macrophyte refers to aquatic plants which are large enough to be seen with the naked eye and whose photosynthetically active parts are permanently, or at least, for several months each year submerged in water or floating on the water surface.

Macrophytes play a very important role in aquatic ecosystems. They provide, either directly or indirectly, food, shelter and a variety of habitats for a large number of organisms, including waterfowl and fish. Macrophytes absorb dissolved minerals and enrich water with oxygen produced during photosynthesis. Rampant growth of aquatic plants may interfere with boating, swimming, angling and other recreational uses.

4.4.1 Aerial Survey

The aerial photographic survey conducted on July 31, 1979, provided an overview of the distribution of macrophytic plant growth in Kenosee Lake. The aerial survey also formed the basis for the locations of the surface transects used during the macrophyte surveys.

Sequential mosaic composite photographs assembled for the four aerial transects provided a record of the appearance of the lake from approximately 1000 feet above the ground level. Patterns of macrophyte distribution were apparent from the photographs for some of the shallow shoreline areas. Poor resolution, low contrast, slight wave action and limited light penetration reduced the discernable detail in the photographs of the deep lake locations. Photographs taken during the Kenosee Lake study have been retained on Saskatchewan Environment files and are available for review upon request.

4.4.2 Surface Surveys

The surface macrophyte surveys conducted on August 2, 3 and 14, 1979, revealed that the bottom vegetation of Kenosee Lake primarily consisted of three plant species. Potamogeton pectinatus, Cladophora species (probably glomerata) and Chara species (probably vulgaris) were identified at most of the transects. Additionally, Myriophyllum excelbescens (milfoil) was observed twice during the survey. Plant growth generally extended to regions with depths of four metres or greater depending on the specific location. A complete transcript of the field observations recorded during the macrophyte survey is available from Saskatchewan Environment file records.

The results of the Department of Tourism and Renewable Resources macrophyte survey including standing biomass and aquatic plant phosphorous content determinations are summarized in Tables 22 and 23 respectively.

A review of Table 22 reveals that the 2 to 4 metre depth zone showed the greatest average standing biomass. Plant growth at some shallow sites (0 to 2 metre zone) may be partially limited by wave action or unsuitable rooting sites. Reduced light penetration may be responsible for the lower standing biomass levels for the greater than four metre depth zone.

TABLE 22

Summary of Standing Biomass of Macrophytic Plants

Depth Zone (m)	% of Total Lake Area*	No. of Samples	Average Standing Biomass (g/m^2)
0 - 2	20.7	24	1559
2 - 4	15.4	21	1812
>4**	63.9	16	1719
Weighted average			1700***

*   1959 survey data
** maximum depth sampled 7.5 m
*** the weighted average standing biomass for 1978 was 2557 g/m^2. Biomass figures are on a fresh weight basis.

TABLE 23

Phosphorous Content of Macrophytic Plants

Species	mg P/kg weed (ppm) On Oven Dry wt. basis*	mg P/kg weed (ppm) On Fresh Wt. basis
Ruppia maritima	3016	362
Potamogeton spp	2880	346
Myriophyllum sp	1495	179
Filamentous green algae	2453	294
Moss	1847	222
Chara sp	8152	978
Average	3307	397

* dry weight x 0.12 = (fresh weight)

Plant species identified by DP & RR (Table 23) were similar to those described in the previous survey performed by Saskatchewan Environment personnel. The plant Ruppia maritima (Table 23) primarily occurs as a species confined to the littoral zones of the lake. The filamentous green algae noted in Table 23 was probably Cladophora glomerata.

The average phosphorous values reported for aquatic plants (Table 23) ranged from 179 mg/Kg for Myriophyllum species to 978 mg/Kg for Chara species (fresh weight basis). It should be noted however, that phosphorous content is somewhat species dependent. When applied with the surface area and weighted mean standing biomass values for the entire lake, the mean phosphorous content results indicated that about 5.2×10^3 Kg (fresh weight) or 43.3×10^3 Kg (dry weight) of phosphorous was associated with living plants in the lake. Theoretically, the abundant growth of aquatic plants with the associated uptake of phosphorous combined with other physical and chemical conditions in Kenosee Lake may function to limit algal growth during summer months.

4.5 Benthos

A survey of the bottom fauna, or benthos, of any lake may be used as an indirect indicator of that lake's productivity and trophic status. Gradual changes in the density and composition of the lake's bottom fauna may be indicative of changes in the water quality and trophic status.

Table 24 provides a summary of the benthos data based on the taxomonic groupings and their depth distribution. Quantitatively, Chironomid (midge) larvae dominated the benthos samples at about 50 per cent of the total counted organisms (Table 24). Gastropods (snails) were second most common at about 21 per cent, and Chaoboridae (phantom midge) larvae constituted 7 per cent of the bottom fauna population. These findings differ from those of Hamilton (1961), who noted that members of the Chironomidae (midge) family (34 per cent) and the Culicidae (phantom midge) family, i.e. *Chaoborus punctipennis* (59 per cent) quantitatively dominated the bottom fauna of the lake. Hamilton (1961) also noted that the last of the *C. punctipennis* pupae were collected on August 15 of the study year. The apparent differences in these findings is probably an artifact of the near post-pupation (*C. punctipennis*) sample collection date (August 14) for the present study.

TABLE 24

Summary of Bottom Fauna Data

Taxonomic Group	Common Name	Stations 1-3 Number Counted	Stations 1-3 % of Total	Stations 8-14 Number Counted	Stations 8-14 % of Total	All Stations Combined Number Counted	All Stations Combined % of Total
Nematomorpha (P)	horsehair worms	2	0.7	0	0	2	0.4
Oligochaeta (C)	aquatic earthworms	2	0.7	0	0	2	0.4
Hirudinea (C)	leeches	3	1.0	0	0	3	0.5
Copepoda (O)	copepods	1	0.4	0	0	1	0.2
Ostracoda (O)	fairy shrimps	0	0	36	13.5	36	6.4
Amphipoda (O)	scuds and side swimmers	22	7.4	12	4.5	34	6.0
Hydracarina (O)	water mites	0	0	4	1.5	4	0.7
Ephemeroptera (O)	Mayflies	4	1.3	0	0	4	0.7
Odonata (O)	dragonflies & damselflies	20	6.7	0	0	20	3.5
Trichoptera (O)	caddisflies	4	1.3	4	1.5	8	1.4
Chironomidae (F)	midges	142	47.8	138	51.7	280	49.6
Chaoboridae (F)	phantom midges	1	0.4	39	14.6	40	7.1
Gastropoda (O)	snails	92	31.0	27	10.1	119	21.1
Pelecypoda (O)	clams	4	1.3	4	1.5	11	2.0
Total		297	100	267	100	564	100

P - Phylum
C - Class
O - Order
F - Family

A further review of Table 24 indicates that the taxomonic groups showed differing spatial distributions. Members of the taxonomic groups of Nematomorpha (horsehair worms), Oligiochaeta (aquatic earthworms), Hirudinea (leeches), Copepoda (copepods), Ephemeroptera (mayflies) and Odonata (dragonflies and damselflies) were found only at the shallow shoreline stations. Members of the taxonomic groupings of Ostracoda (fairy shrimps) and Hydracarina (water mites) were only identified from samples collected at deeper mid-lake stations.

The average standing crop in terms of the number of organisms per square metre was also calculated from the bottom fauna data. Mean standing crop values of 4400 orgs/m^2, 1695 orgs/m^2 and 2506 orgs/m^2 were calculated for the shallow shoreline stations, deeper mid-lake stations and all stations combined, respectively.

High standing crop figures and an aquatic fly (Chironomidae and Chaoboridae) and snail (Gastropoda) dominated benthos population indicate a eutrophic status for Kenosee Lake.

4.6 Fish

Kenosee Lake is the only water body within the park boundaries capable of supporting fish on a year round basis. Perch and northern pike are the only species found in significant numbers in Kenosee Lake. In a 1979 study Christensen (1980) noted that pH levels were too high to permit natural reproduction of walleye, northern pike and common suckers. Additionally, winter oxygen levels may be a factor limiting walleye survival (Christensen, 1980). Populations of northern pike in Kenosee Lake are maintained by the operation of a fish rearing pond. Partial winter fish kills have been documented for 1977-78, 1978-79 and 1979-80 (Christensen, 1980).

Generally, fish tend to accumulate many substances and contaminants present in concentrations which are not detectable by water analysis techniques. Therefore analysis of fish muscle tissue is an important tool for monitoring the levels of trace substances in a water body. Additionally, fish muscle tissue should be monitored to determine if it complies with consumptive guidelines. The results of perch and northern pike muscle tissue analysis are presented in Table 25. Table 26 provides a summary of the available pertinent consumptive guidelines and legal limits.

Although the sample size was relatively small, only six northern pike and eleven perch were submitted for analysis (Table 25), all values for trace metals and pesticides fell within the consumptive guidelines (Table 26). Based on the

TABLE 25

Summary of Fish Muscle Tissue Data

Species	# Samples	Analysis Type	Mean (ppm)	Range (ppm)
northern pike	6	Mercury	0.29	0.21-0.44
		Cadmium	<0.01	<0.01-<0.01
		Lead	<0.05	<0.05-<0.05
		Copper	0.20	0.19-0.21
		Zinc	4.34	3.40-5.51
		Chromium	<0.10	<0.10-0.11
		Arsenic	0.03	0.02-0.04
		Nickel	0.17	0.16-0.18
		Selenium	0.16	0.14-0.18
		Total PCBs	<0.015	<0.015-<0.015
		Total DDT	<0.006	<0.006-<0.006
		Dieldrin	<0.001	<0.001-<0.001
		Methoxychlor	<0.008	<0.008-<0.008
		Lindane	<0.001	<0.001-<0.001
yellow perch	11	Mercury	0.14	0.10-0.21
		Cadmium	<0.01	<0.01-<0.01
		Lead	<0.05	<0.05-<0.05
		Copper	0.20	0.14-0.46
		Zinc	5.28	4.40-6.21
		Chromium	<0.10	<0.10-<0.10
		Arsenic	0.02	0.01-0.03
		Nickel	0.16	0.13-0.21
		Selenium	0.13	0.10-0.15
		Total PCBs	<0.015	<0.015-<0.015
		Total DDT	<0.006	<0.006-<0.006
		Dieldrin	<0.001	<0.001-<0.001
		Methoxychlor	<0.008	<0.008-<0.008
		Lindane	<0.001	<0.001-<0.001

TABLE 26
Summary of Fish and Food Consumptive Guidelines and Legal Limits

	Canadian Food and Drug Regulations 1981	USA Food and Drug Administration 1983 Action Levels	Food and Agriculture Organization (United Nations) 1983 Legal Limits
Mercury	0.5 ppm	1.0 ppm	0.5 ppm
Cadmium	-	-	-
Lead	0.5 ppm	-	0.5 ppm
Copper	Total 50 ppm**	-	-
Zinc	-	-	-
Chromium	-	-	-
Arsenic	-	-	3.5 ppm
Nickel	-	-	-
Selenium	-	-	-
Total PCBs	-	3 ppm*	2.0 ppm
Total DDT	5.0 ppm	5.0 ppm	5.0 ppm
Dieldrin	0.2 ppm for meat*	0.3 ppm	0.1 ppm
Methoxychlor	3.0 ppm for meat*	-	-
Lindane	0.7 ppm for meat*	0.1 ppm***	-

* values for meat have been quoted since levels for fish are not available.

** values for fruit and vegetables

*** value specified for human food only

limited data, northern pike and perch were safe for human consumption as far as can be determined from the available guidelines. Additional monitoring of mercury in the game fish species present in the lake should be undertaken and in order to reaffirm their consumptive quality since the sample size was small.

5. ACKNOWLEDGEMENTS

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WATER QUALITY MONITORING
PROCEDURAL METHODS AND DETAILS

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Table A-1

Summary of Physical Parameter and Field Measurement Determination Details

Parameter	Location	Frequency	Equipment Used
Dissolved O_2 & Temperature (Instantaneous)	Stations 1 through 14 inclusive	Every visit at 1 metre intervals	YSI 57 DO/Temp. meter
Specific Conductance	Stations 1 through 14 inclusive	Once per day during daylight hours on same day for all samples	Beckman RB-5 Conductivity meter
pH	Stations 1 through 14 inclusive	Once per day during daylight hours on same day for all samples	Metrohon E-488 pH meter
Secchi depth	Stations 1 through 14 inclusive	Once per day on same day for all readings	Standard 20 cm dia. Secchi disc.

Table A-2

Summary of Water Quality Parameter Groupings

Group 1	Group 2	Group 3
Total Kjeldahl Nitrogen (TKN)	Total Suspended Solids (TSS)	Fecal Coliforms (F coli)
Total Phosphorous (TP)	Volatile Suspended Solids (VSS)	Fecal Streptococci (F. strep.)
Five Day Biological Oxygen Demand (BOD_5)	Total Organic Carbon (TOC)	
Total Coliform (T. coli)	Ammonia-Nitrogen (NH_3-N)	
Conductivity at 25°C (cond.)	Nitrate-Nitrite Nitrogen (NO_3-NO_2 N)	
pH (Hydrogen Iron Concentration)	Ortho Phosphorous (Ortho P)	
Chloride (Cl)	Chlorophyll "a" (chloro a)	
	Iron (Fe)	
	Manganese (Mn)	

Table A-3

Summary of Esquadat Parameter Codes

Parameter	Esquadat Code Number
Total Kjeldahl Nitrogen (TKN)	07016L
Nitrate-Nitrite (NO_3 - NO_2 N)	07109L
Ammonia-Nitrogen (NH_3-N)	07506L
Total Phosphorous (TP)	15409L
Ortho Phosphorous (Ortho P)	15206L
Five Day Biological Oxygen Demand (BOD_5)	08202L
Total Suspended Solids (TSS)	10406L
Volatile Suspended Solids (VSS)	10521L
Chlorophyll a (chloro a)	06708L
Total Organic Carbon (TOC)	06008L
Total Coliform Bacteria (T. coli)	36002L
Fecal Coliform Bacteria (F. coli)	36012L
Fecal Streptococci Bacteria (F. Strep.)	36102L
Conductivity at 25°C (cond.)	02041L
pH (Hydrogen Iron Concentration)	10301L
Chloride (Cl)	17204L
Iron (Fe)	26007L
Manganese (Mn)	25004L

APPENDIX B

PHYTOPLANKTON DATA

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Table B-1

Relative Quantitative and Volumetric Dominance - Chlorophyta Species

	August 22-24/79			February 18-20/80			May 26-28/80		
Chlorophyta	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %
Botryococcus braunii	0	NF	NF	2	<1	3	1	NE	NE
Crucigenia rectangularis	12	4	<1	0	NF	NF	1	<1	<1
Dictyosphaerium pulchellum	0	NF	NF	0	NF	NF	1	1	<1
Elaktothrix viridis	0	NF	NF	0	NF	NF	6	3	<1
Lagerheimia ciliata	1	NE	NE	0	NF	NF	0	NF	NF
Monoraphidium contortum	0	NF	NF	8	<1	<1	0	NF	NF
Monoraphidium minutum	0	NF	NF	3	<1	<1	0	NF	NF
Oocystis borgei	6	<1	<1	0	NF	NF	9	3	1
Oocystis crassa	1	<1	<1	0	NF	NF	7	<1	1
Oocystis lacustris	1	<1	<1	0	NF	NF	0	NF	NF
Oocystis parva	0	NF	NF	0	NF	NF	3	1	<1
Oocystis pusilla	5	<1	<1	0	NF	NF	6	1	<1
Oocystis sumarina	10	1	<1	0	NF	NF	3	1	<1
Pediastrum boryanum	3	<1	<1	3	<1	1	1	NE	NE
Pediastrum duplex	1	NE	NE	0	NF	NF	0	NF	NF
Planktosphaeria gelatinosa	1	<1	<1	0	NF	NF	5	<1	<1
Quadrigula chodaii	2	<1	<1	0	NF	NF	0	NF	NF
Scenedesmus acuminatus	1	NE	NE	3	<1	<1	0	NF	NF
Scenedesmus ecornis	4	<1	<1	0	NF	NF	0	NF	NF
Scenedesmus quadicauda	0	NF	NF	1	<1	<1	0	NF	NF
Schroederia judayi	0	NF	NF	1	<1	<1	0	NF	NF
Schroederia setigera	0	NF	NF	1	<1	<1	0	NF	NF
Sphaerocystis schroeteri	11	3	<1	0	NF	NF	9	4	<1
Tetraedron minimum	6	<1	<1	2	NE	NE	0	NF	NF
Total	-	9	<1	-	<1	4	-	14	3

Key:
Ob. - records the number of samples in which a particular species was identified.
NE - not enumerated, but present
NF - not found

Table B-2

Relative Quantitative and Volumetric Dominance - Chrysophyta Species

Chrysophyta	August 22-24/79			February 18-20/80			May 26-28/80		
	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %
Achnanthes minutissima	0	NF	NF	0	NF	NF	1	<1	<1
Asterionella formosa	0	NF	NF	13	4	14	9	<1	<1
Chrysochromulina parva	0	NF	NF	22	9	2	13	34	1
Cocconesis placentula	9	1	<1	0	NF	NF	0	NF	NF
Cyclonexsis annularis	0	NF	NF	1	NE	NE	0	NF	NF
Cymatopleura solea	0	NF	NF	3	NE	NE	1	NE	NE
Diatoma elongatum	0	NF	NF	28	5	17	10	1	<1
Fragilaria crotonensis	10	2	<1	0	NF	NF	13	2	2
Gomphonema olivaceum	1	<1	<1	0	NF	NF	0	NF	NF
Nitzschia acicularis	4	<1	<1	3	<1	<1	8	1	<1
Rhoicosphenia curvata	5	<1	<1	3	NE	NE	0	NF	NF
Rhopalodia gibba	2	<1	<1	1	NE	NE	0	NF	NF
Stephanodiscus niagarae	1	NE	NE	0	NF	NF	0	NF	NF
Synedra ulna	4	<1	<1	0	NF	NF	0	NF	NF
Total	-	3	1	-	18	33	-	38	3

Key:
Ob. - records the number of samples in which a particular species was identified.
NE - not enumerated, but present
NF - not found

Table B-3

Relative Quantitative and Volumetric Dominance -
Cyanophyta Species

	August 22-24/79			February 18-20/80			May 26-28/80		
Cyanophyta	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %
Anabaena contricta	1	NE	NE	0	NF	NF	0	NF	NF
Anabaena Flos-aquae	13	1	<1	0	NF	NF	1	NE	NE
Aphanocapsa delicatissima	12	47	61	0	NF	NF	0	NF	NF
Aphanocapsa elachista	6	<1	<1	0	NF	NF	0	NF	NF
Aphanothece clathrata	13	26	37	0	NF	NF	11	1	87
Chroococcus limneticus	13	8	<1	0	NF	NF	1	<1	<1
Coelosphaerium kuetzingianum	0	NF	NF	0	NF	NF	4	<1	1
Lyngbya limnetica	5	<1	<1	0	NF	NF	0	NF	NF
Merismopedia punctata	4	<1	<1	0	NF	NF	0	NF	NF
Merismopedia tenuissima	2	1	<1	0	NF	NF	0	NF	NF
Microcystis aeruginosa	0	NF	NF	0	NF	NF	1	NE	NE
Oscillatoria agardhii	4	<1	<1	1	<1	<1	0	NF	NF
Oscillatoria angusta	0	NF	NF	6	1	<1	0	NF	NF
Oscillatoria chalybea	3	<1	<1	0	NF	NF	0	NF	NF
Oscillatoria limnetica	0	NF	NF	1	NE	NE	0	NF	NF
Oscillatoria nigra	2	<1	<1	0	NF	NF	0	NF	NF
Oscillatoria splendida	1	<1	<1	0	NF	NF	0	NF	NF
Pseudanabaena catenata	9	<1	<1	0	NF	NF	1	<1	<1
Total	-	83	99	-	1	1	-	1	89

Key:
Ob. - records the number of samples in which a particular species was identified.
NE - not enumerated, but present
NF - not found

Table B-4

Relative Quantitative and Volumetric Dominance - Pyrrhophyta Species

Pyrrhophyta	August 22-24/79			February 18-20/80			May 26-28/80		
	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %
Ceratium hirundinella	12	<1	1	0	NF	NF	0	NF	NF
Chroomonas acuta	0	NF	NF	38	81	62	13	43	4
Cryptomonas marssunii	0	NF	NF	0	NF	NF	3	<1	<1
Rhodomonas minuta	4	4	<1	1	<1	<1	5	4	<1
Total	-	4	<1	-	81	62	-	47	5

Key:
Ob. - records the number of samples in which a particular species was identified.
NE - not enumerated, but present
NF - not found

Table B-5

Relative Quantitative and Volumetric Dominance - Euglenophyta Species

Euglenophyta	August 22-24/79			February 18-20/80			May 26-28/80		
	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %	Ob.	Quant. %	Vol. %
Euglena acus	0	NF	NF	1	<1	<1	0	NF	NF
Total	-	NF	NF	-	<1	<1	-	NF	NF

Key:
Ob. - records the number of samples in which a particular species was identified.
NE - not enumerated, but present
NF - not found

APPENDIX C

DISSOLVED OXYGEN, TEMPERATURE AND PER CENT SATURATION PROFILE RECORDS

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
1	79-08-13	11:30	surface 1.0	15 16	7.5 7.2	81 80	1.0
	79-08-13	17:20	surface 1.0	17 17	9.7 9.8	109 110	1.5
	79-08-13	20:05	surface 1.0	16.5 16.5	9.1 8.8	102 98	1.0
	79-08-14	00:05	surface 1.0	15.5 15.5	8.5 8.6	93 94	1.1
	79-08-14	05:20	surface 1.0	14.5 14.5	7.8 7.7	83 82	1.1
	79-08-14	09:30	surface 1.0	15 15	6.3 6.3	68 68	1.4
	79-08-14	13:30	surface 1.0	17 17	6.7 6.7	76 76	1.8
	79-08-15	09:20	surface 1.0	15.5 15.5	8.5 8.5	93 93	1.5
2	79-08-13	16:20	surface 1.0	16.5 16.5	9.4 9.1	105 102	1.5
	79-08-13	18:50	surface 1.0	16.0 16.0	12.0 12.0	133 133	1.3
	79-08-13	22:45	surface 1.0	15.0 15.0	9.7 9.6	105 104	1.7
	79-08-14	01:45	surface 1.0	15.0 15.0	9.7 9.7	105 105	-
	79-08-14	05:30	surface 1.0	14.5 14.5	8.4 8.3	90 89	1.5
	79-08-14	10:50	surface 1.0	14.5 15.0	6.2 5.9	66 64	1.5
	79-08-14	15:35	surface 1.0	16.5 16.5	10.5 10.5	117 117	1.7
	79-08-15	10:30	surface 1.0	17.0 17.0	9.4 9.4	106 106	1.5

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
3	79-08-13	16:30	surface	17.0	10.8	122	1.5
			1.0	17.0	10.5	118	
	79-08-13	18:55	surface	16.5	11.2	125	1.1
			1.0	16.5	11.0	123	
	79-08-13	23:00	surface	14.5	9.1	97	1.0
			1.0	15.0	9.0	97	
	79-08-14	01:55	surface	15.0	9.1	98	-
			1.0	15.0	8.9	96	
	79-08-14	05:35	surface	14.5	7.9	84	1.5
			1.0	14.5	7.8	83	
	79-08-14	11:00	surface	15.0	6.8	74	1.2
			1.0	15.0	6.7	72	
	79-08-14	15:45	surface	16.5	11.6	130	1.0
			1.0	16.5	11.6	130	
	79-08-15	10:40	surface	16.5	10.2	114	1.0
			1.0	16.5	10.2	114	
4	79-08-13	16:45	surface	16.0	12.0	133	1.0
			1.0	16.0	12.0	133	
	79-08-13	19:05	surface	16.0	11.8	130	1.0
			1.0	16.0	11.8	130	
	79-08-13	23:10	surface	15.0	9.6	104	1.5
			1.0	15.0	9.6	104	
	79-08-14	02:05	surface	15.0	8.2	89	-
			1.0	14.5	8.3	89	
	79-08-14	05:40	surface	15.0	7.8	84	1.2
			1.0	15.0	8.0	87	
	79-08-14	11:10	surface	16.0	7.1	79	1.0
			1.0	16.0	6.9	76	
	79-08-14	15:50	surface	16.5	10.5	117	1.0
			1.0	16.5	10.3	115	
	79-08-15	10:45	surface	17.0	9.4	106	1.6
			1.0	17.5	9.4	107	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
5	79-08-13	14:40	surface 1.0	16.0 16.0	9.9 9.9	109 109	1.0
	79-08-13	18:45	surface 1.0	16.0 16.0	11.8 11.8	130 130	1.0
	79-08-13	23:25	surface 1.0	14.5 14.5	8.6 8.4	92 90	1.5
	79-08-13	02:10	surface 1.0	15.0 15.0	7.4 7.3	80 79	-
	79-08-14	05:45	surface 1.0	14.0 14.5	7.3 7.0	77 75	1.5
	79-08-14	11:15	surface 1.0	15.0 15.0	7.0 7.0	76 76	1.2
	79-08-14	16:05	surface 1.0	16.0 16.5	11.6 11.6	128 130	1.1
	79-08-15	10:55	surface	15.0	10.1	109	0.9
6	79-08-13	10:25	surface 1.0 2.0	14.5 15.0 15.0	9.2 9.4 9.3	98 102 101	2.0
	79-08-13	15:00	surface 1.0 2.0	16.0 16.0 16.0	9.0 9.0 8.8	99 99 97	2.0
	79-08-13	18:40	surface 1.0	16.0 16.5	9.0 9.2	99 103	2.0
	79-08-14	02:20	surface 1.0	15.0 15.0	8.6 8.6	93 93	-
	79-08-14	05:50	surface 1.0	14.5 14.5	8.5 8.3	91 89	1.3
	79-08-14	11:25	surface 1.0 2.0	15.0 15.5 15.5	7.9 7.8 7.9	85 85 85	2.0
	79-08-14	16:15	surface 1.0 2.0	16.5 17.0 16.5	9.8 9.8 11.6	110 110 130	2.1
	79-08-15	11:00	surface 1.0	16.5 16.5	9.7 9.4	108 105	1.6

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
7	79-08-13	15:10	surface	16.5	10.6	118	1.7
			1.0	16.5	10.6	118	
	79-08-13	18:30	surface	16.0	12.1	134	1.0
			1.0	16.0	12.0	133	
	79-08-13	23:35	surface	14.5	10.4	111	1.5
			1.0	14.5	10.3	110	
	79-08-14	02:30	surface	15.5	8.6	94	-
			1.0	16.0	8.6	95	
	79-08-14	05:55	surface	15.0	8.3	90	1.5
			1.0	15.0	8.2	89	
	79-08-14	11:30	surface	15.5	6.8	74	1.7
			1.0	15.5	6.8	74	
	79-08-14	16:25	surface	17.5	10.6	121	1.3
			1.0	17.0	10.7	125	
	79-08-15	11:10	surface	17.0	9.8	110	1.8
			1.0	17.0	9.7	109	
8	79-08-13	11:50	surface	15.0	6.6	71	5.0
			1.0	15.0	6.6	71	
			2.0	15.5	6.6	72	
			3.0	15.5	6.4	70	
			4.0	15.5	6.4	70	
			5.0	15.5	6.5	71	
	79-08-13	17:30	surface	16.0	8.5	94	4.6
			1.0	16.0	8.5	94	
			2.0	16.0	8.3	92	
			3.0	16.0	8.3	92	
			4.0	16.0	8.3	92	
	79-08-13	20:10	surface	16.0	7.7	85	4.5
			1.0	16.0	7.7	85	
			2.0	16.0	7.6	84	
			3.0	16.0	7.5	83	
			4.0	16.0	7.4	82	
	79-08-14	00:10	surface	15.0	8.5	92	5.0
			1.0	15.0	8.3	90	
			2.0	15.5	8.1	89	
			3.0	15.5	8.2	90	
			4.0	15.5	8.2	90	
			5.0	15.5	8.2	90	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
8 cont'd.	79-08-14	05:10	surface	15.0	7.7	83	5.0
			1.0	15.0	7.7	83	
			2.0	15.0	7.7	83	
			3.0	15.0	7.6	82	
			4.0	15.0	7.5	81	
			4.5	15.0	7.3	80	
	79-08-14	09:35	surface	14.5	7.1	76	4.8
			1.0	15.0	7.1	77	
			2.0	15.0	6.9	75	
			3.0	15.0	6.9	75	
			4.0	15.0	6.0	65	
	79-08-14	13:40	surface	15.5	7.8	85	5.0
			1.0	16.0	7.5	83	
			2.0	16.0	7.5	83	
			3.0	16.0	7.5	83	
			4.0	15.0	8.7	94	
			5.0	15.0	9.0	97	
	79-08-15	09:35	surface	17.0	8.2	92	5.0
			1.0	17.0	7.8	88	
			2.0	17.0	7.9	89	
			3.0	17.0	7.9	89	
			4.0	17.5	7.7	88	
			5.0	17.5	7.7	88	
9	79-08-13	12:10	surface	15.0	7.0	76	6.0
			1.0	15.0	7.0	76	
			2.0	15.5	7.0	76	
			3.0	15.5	6.9	75	
			4.0	15.5	6.9	75	
			5.0	16.0	6.7	74	
			6.0	16.0	5.8	64	
	79-08-13	17:40	surface	16.5	8.6	96	6.0
			1.0	16.5	8.6	96	
			2.0	16.5	8.4	94	
			3.0	16.5	8.4	94	
			4.0	16.5	8.4	94	
			5.0	16.5	8.2	92	
			6.0	16.0	8.0	88	
	79-08-13	20:20	surface	16.5	8.2	92	6.1
			1.0	16.5	7.8	87	
			2.0	16.5	7.7	86	
			3.0	17.0	7.8	88	
			4.0	17.0	7.8	88	
			5.0	17.0	7.8	88	
			6.0	17.0	7.6	86	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
9 cont'd.	79-08-14	00:25	surface	16.0	8.3	92	6.0
			1.0	16.0	8.3	92	
			2.0	16.0	7.8	86	
			3.0	16.0	7.9	87	
			4.0	16.0	7.8	86	
			5.0	16.5	7.8	87	
			6.0	16.5	7.8	87	
	79-08-14	04:55	surface	15.5	7.5	82	5.5
			2.0	15.5	7.5	82	
			3.0	16.0	7.5	83	
			4.0	16.0	7.4	82	
			5.0	16.0	7.4	82	
			5.5	16.0	7.2	80	
	79-08-14	09:45	surface	15.0	6.0	65	6.0
			1.0	15.0	6.1	66	
			2.0	15.0	6.1	66	
			3.0	15.0	6.0	65	
			4.0	15.5	5.8	63	
			5.0	15.5	5.7	62	
			6.0	15.5	5.6	61	
	79-08-14	13:55	surface	16.0	8.4	93	6.0
			1.0	16.5	8.3	93	
			2.0	16.5	8.3	93	
			3.0	16.5	8.2	92	
			4.0	16.0	8.0	88	
			5.0	16.0	7.8	86	
			6.0	16.0	7.8	86	
	79-08-15	09:40	surface	17.5	8.6	98	6.0
			1.0	18.0	8.4	97	
			2.0	18.0	8.4	97	
			3.0	18.0	8.4	97	
			4.0	18.0	8.4	97	
			5.0	18.0	8.4	97	
			6.0	18.0	8.1	93	
10	79-08-13	13:45	surface	16.0	8.9	98	7.0
			1.0	16.0	8.9	98	
			2.0	16.0	8.6	95	
			3.0	16.0	8.4	93	
			4.0	16.5	8.2	92	
			5.0	16.5	7.8	87	
			6.0	16.5	7.8	87	
			7.0	16.5	7.8	87	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
10 cont'd.	79-08-13	17:45	surface	16.0	9.6	106	7.5
			1.0	16.0	9.6	106	
			2.0	16.0	9.4	104	
			3.0	16.0	9.4	104	
			4.0	16.0	9.2	102	
			5.0	16.0	9.2	102	
			6.0	16.5	9.0	101	
			7.0	16.5	9.0	101	
	79-08-13	20:30	surface	16.0	9.0	99	7.0
			1.0	16.0	8.9	98	
			2.0	16.0	8.9	98	
			3.0	16.0	8.6	95	
			4.0	16.5	8.6	96	
			5.0	16.5	8.6	96	
			6.0	16.5	8.5	95	
			6.5	16.5	8.3	93	
	79-08-14	00:35	surface	16.0	9.2	102	7.0
			1.0	16.0	9.0	99	
			2.0	16.0	8.9	98	
			3.0	16.0	8.9	98	
			4.0	16.5	8.8	98	
			5.0	16.5	8.8	98	
			6.0	16.5	8.6	96	
			7.0	16.5	8.6	96	
	79-08-14	04:45	surface	15.0	8.7	94	7.0
			1.0	15.5	8.5	93	
			2.0	16.0	8.4	93	
			3.0	16.0	8.2	91	
			4.0	16.0	8.4	93	
			5.0	16.0	8.2	91	
			6.0	16.0	8.2	91	
			6.5	16.0	8.2	91	
	79-08-14	09:55	surface	15.0	7.2	78	7.2
			1.0	15.0	7.1	77	
			2.0	15.0	7.0	76	
			3.0	15.0	6.4	69	
			4.0	15.5	6.4	70	
			5.0	15.5	6.4	70	
			6.0	15.5	6.0	66	
			7.0	15.5	6.0	66	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
10 cont'd.	79-08-14	14:20	surface	16.0	9.1	101	7.4
			1.0	16.0	9.1	101	
			2.0	16.0	8.9	98	
			3.0	16.0	8.9	98	
			4.0	16.0	8.7	96	
			5.0	16.0	8.5	94	
			6.0	15.5	8.2	90	
			7.0	15.5	8.2	90	
	79-08-15	09:50	surface	17.0	9.2	104	7.0
			1.0	17.5	9.0	102	
			2.0	17.5	8.8	100	
			3.0	17.5	8.6	98	
			4.0	17.5	8.6	98	
			5.0	18.0	8.8	101	
			6.0	17.5	8.4	96	
			7.0	18.0	8.4	97	
11	79-08-13	16:00	surface	16.0	8.6	95	5.2
			1.0	16.0	8.5	94	
			2.0	16.0	8.4	93	
			3.0	16.0	8.4	93	
			4.0	16.0	8.5	94	
			5.0	16.0	8.5	94	
	79-08-13	18:20	surface	16.5	9.0	101	5.0
			1.0	16.5	8.9	99	
			2.0	16.5	8.8	98	
			3.0	16.5	8.8	98	
			4.0	16.5	8.6	96	
			5.0	16.5	8.6	96	
	79-08-13	22:00	surface	14.5	9.1	97	-
			1.0	15.0	8.9	96	
			2.0	15.0	8.9	96	
			3.0	15.0	8.9	96	
			4.0	15.0	8.8	95	
			5.0	15.5	8.5	93	
	79-08-14	00:50	surface	16.0	8.5	94	4.5
			1.0	16.0	8.4	93	
			2.0	16.0	8.3	92	
			3.0	16.0	8.1	90	
			4.0	16.0	8.0	88	
			4.5	16.0	7.9	87	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
11 cont'd.	79-08-14	04:40	surface	14.5	8.3	86	4.5
			1.0	15.0	8.2	89	
			2.0	15.0	8.0	87	
			3.0	15.5	8.1	89	
			4.0	15.5	8.1	89	
			4.5	15.5	7.6	83	
	79-08-14	10:40	surface	15.0	5.4	58	4.5
			1.0	15.0	5.4	58	
			2.0	15.0	5.3	57	
			3.0	15.0	5.3	57	
			4.0	15.0	5.7	62	
	79-08-14	15:10	surface	15.5	8.5	93	5.0
			1.0	16.0	8.5	94	
			2.0	16.0	7.8	86	
			3.0	16.0	7.8	86	
			4.0	15.5	8.2	90	
			5.0	15.5	8.5	93	
	79-08-15	10:20	surface	17.0	8.4	95	5.0
			1.0	17.5	8.4	96	
			2.0	17.5	8.2	93	
			3.0	17.5	8.4	96	
			4.0	17.5	8.2	93	
			5.0	17.5	8.0	91	
12	79-08-13	15:20	surface	16.0	9.4	104	1.8
			1.0	16.0	9.3	103	
			1.8	16.0	9.4	104	
	79-08-13	18:00	surface	16.0	9.9	109	1.2
			1.0	16.0	9.9	109	
	79-08-14	01:00	surface	15.5	9.7	106	-
			1.0	15.5	9.7	106	
			2.0	15.5	9.5	104	
			3.0	15.5	9.2	101	
			4.0	15.5	9.2	101	
			5.0	15.5	9.2	101	
			6.0	15.5	9.1	101	
			7.0	15.5	8.8	96	
			7.5	15.5	8.8	96	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
12 cont'd.	79-08-14	04:30	surface	15.0	9.0	97	7.3
			1.0	15.0	8.8	95	
			2.0	15.0	8.8	95	
			3.0	15.0	8.6	93	
			4.0	15.0	8.8	95	
			5.0	15.5	8.8	96	
			6.0	15.5	8.5	93	
			7.0	15.5	8.4	92	
	79-08-14	10:30	surface	14.5	6.5	69	6.5
			1.0	15.0	6.6	71	
			2.0	15.0	6.5	70	
			3.0	15.0	6.5	70	
			4.0	15.0	6.4	69	
			5.0	15.0	6.4	69	
			6.0	15.0	6.3	68	
	79-08-14	15:00	surface	15.5	9.5	104	6.8
			1.0	15.5	9.5	104	
			2.0	16.0	9.4	104	
			3.0	15.5	9.3	102	
			4.0	15.5	9.2	101	
			5.0	15.5	9.2	101	
			6.0	15.5	8.9	97	
	79-08-15	10:10	surface	17.0	9.0	101	7.0
			1.0	17.5	8.9	101	
			2.0	17.5	8.8	100	
			3.0	17.5	8.8	100	
			4.0	17.5	8.7	99	
			5.0	17.5	8.7	99	
			6.0	17.5	8.5	97	
			7.0	17.0	8.3	94	
13	79-08-13	15:30	surface	15.0	9.5	103	4.0
			1.0	15.0	9.5	103	
			2.0	15.0	9.5	103	
			3.0	15.5	9.4	103	
			4.0	15.5	9.2	101	
	79-08-13	18:10	surface	15.5	9.2	101	4.0
			1.0	15.5	9.1	100	
			2.0	15.5	9.0	98	
			3.0	15.5	8.7	95	
			4.0	15.5	8.6	94	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
13 cont'd.	79-08-13	21:35	surface	14.5	9.5	101	3.5
			1.0	14.5	9.7	104	
			2.0	15.0	9.7	105	
			3.0	15.0	9.3	101	
	79-08-14	01:15	surface	15.0	9.5	103	-
			1.0	15.0	9.5	103	
			2.0	15.0	9.4	102	
			2.5	15.0	9.3	101	
	79-08-14	04:20	surface	14.5	8.7	93	4.5
			1.0	14.5	8.6	92	
			2.0	14.5	8.6	92	
			3.0	14.5	8.6	92	
			4.0	14.5	8.5	91	
	79-08-14	10:15	surface	14.0	6.8	72	4.0
			1.0	14.5	6.8	73	
			2.0	14.5	6.4	68	
			3.0	14.5	6.4	68	
			4.0	14.0	5.8	61	
	79-08-14	14:50	surface	15.5	9.4	103	4.0
			1.0	15.5	9.8	107	
			2.0	15.5	10.0	109	
			3.0	15.0	10.0	108	
			4.0	15.0	9.8	106	
	79-08-15	10:05	surface	16.5	9.4	105	4.2
			1.0	17.0	9.4	106	
			2.0	17.0	9.1	103	
			3.0	16.5	9.1	102	
			4.0	16.5	9.0	101	
14	79-08-13	14:00	surface	16.0	9.4	104	4.5
			1.0	16.0	9.2	102	
			2.0	16.0	9.0	100	
			3.0	16.0	9.0	100	
			4.0	16.0	8.9	98	
	79-08-13	15:50	surface	16.5	9.2	103	4.0
			1.0	16.5	9.2	103	
			2.0	16.5	9.2	103	
			3.0	16.5	8.9	99	
			4.0	16.5	8.8	98	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
14 cont'd.	79-08-13	21:10	surface	15.0	9.1	98	3.5
			1.0	15.5	9.3	102	
			2.0	15.5	9.2	101	
			3.0	15.5	9.2	101	
	79-08-14	01:30	surface	15.0	9.6	104	-
			1.0	15.0	9.6	104	
			2.0	15.0	9.5	103	
			3.0	15.0	9.5	103	
			4.0	15.0	9.6	104	
			4.5	15.0	9.3	101	
	79-08-14	04:05	surface	15.0	9.1	98	4.0
			1.0	15.0	9.2	100	
			2.0	15.0	9.2	100	
			3.0	15.0	9.0	97	
			4.0	15.0	8.7	94	
	79-08-14	10:10	surface	14.5	6.6	70	4.5
			1.0	15.0	6.6	71	
			2.0	15.0	6.4	69	
			3.0	14.5	6.4	68	
			4.0	14.5	6.0	64	
	79-08-14	14:35	surface	16.0	9.0	99	5.0
			1.0	16.0	9.0	99	
			2.0	16.0	8.8	97	
			3.0	15.0	8.7	94	
			4.0	15.0	8.9	96	
			5.0	15.0	8.8	95	
	79-08-15	10:00	surface	16.5	9.5	106	5.0
			1.0	16.5	9.3	104	
			2.0	17.0	8.9	100	
			3.0	17.0	8.9	100	
			4.0	17.0	8.8	99	
			5.0	17.0	8.8	99	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
1	79-10-22	14:05	surface	4.5	9.7	84	2.0
			1.0	4.5	9.7	84	
	79-10-23	12:45	surface	3.5	12.0	99	1.1
			1.0	3.5	12.0	99	
	79-10-24	10:45	surface	3.0	9.3	78	1.5
			1.0	3.0	9.2	77	
2	79-10-22	12:25	surface	5.0	9.4	84	2.5
			1.0	5.0	9.6	85	
			2.0	5.0	9.4	84	
	79-10-23	11:05	surface	3.0	11.0	91	1.0
			1.0	3.0	11.0	91	
	79-10-24	09:15	surface	2.5	8.6	68	1.0
			1.0	2.5	8.6	68	
3	79-10-22	12:30	surface	4.5	9.6	83	1.0
			1.0	4.5	9.5	82	
	79-10-23	11:15	surface	3.5	12.2	100	1.0
			1.0	3.5	12.2	100	
	79-10-24	09:20	surface	3.5	9.3	78	1.0
			1.0	3.5	9.2	77	
4	79-10-22	12:40	surface	5.0	10.2	87	1.5
			1.0	5.0	10.2	87	
	79-10-23	11:20	surface	4.2	12.2	102	1.0
			1.0	4.2	12.2	102	
	79-10-24	09:30	surface	4.0	9.3	79	1.5
			1.0	4.0	9.3	79	
5	79-10-22	12:50	surface	5.0	9.9	86	1.0
			1.0	5.0	9.9	86	
	79-10-23	11:35	surface	1.8	12.2	97	1.0
			1.0	1.8	12.1	98	
	79-10-24	09:40	surface	2.0	9.4	76	1.0
			1.0	2.0	9.2	74	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
6	79-10-22	13:00	surface 1.0 2.0	5.3 5.0 4.8	9.7 9.7 9.7	86 85 84	2.5
	79-10-23	11:45	surface 1.0	2.0 2.0	12.3 12.3	98 98	1.0
	79-10-24	09:45	surface 1.0	3.0 3.0	9.4 9.4	78 78	1.0
7	79-10-22	13:05	surface 1.0	5.0 4.5	10.0 9.9	86 85	1.0
	79-10-23	11:50	surface 1.0	2.8 2.8	12.5 12.5	102 102	1.5
	79-10-24	09:50	surface 1.0	2.5 2.5	9.5 9.5	78 78	1.0
8	79-10-22	12:15	surface 1.0 2.0 3.0 4.0	4.0 4.0 4.0 4.0 4.0	10.6 10.2 10.2 10.2 10.2	91 87 87 87 87	4.5
	79-10-23	10:50	surface 1.0 2.0 3.0 4.0	3.5 3.5 3.5 3.5 3.5	11.8 11.7 11.6 11.5 11.5	99 98 97 97 97	5.0
	79-10-24	09:00	surface 1.0 2.0 3.0 4.0	3.5 3.5 3.5 3.5 3.5	9.2 9.0 8.9 8.8 8.8	77 76 75 75 75	4.5
9	79-10-22	12:45	surface 1.0 2.0 3.0 4.0 5.0	5.0 5.0 5.0 5.0 5.0 5.0	9.5 9.6 9.8 9.8 9.8 9.8	83 83 85 85 85 85	6.0

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
9 cont'd.	79-10-23	11:25	surface	4.5	12.2	103	6.5
			1.0	4.6	11.6	99	
			2.0	4.5	11.5	97	
			3.0	4.4	11.5	96	
			4.0	4.3	11.5	96	
			5.0	4.3	11.2	93	
			6.0	4.2	10.9	91	
	79-10-24	09:35	surface	4.0	9.2	79	6.0
			1.0	4.0	9.1	78	
			2.0	4.0	9.1	78	
			3.0	4.0	9.0	77	
			4.0	4.0	8.9	76	
			5.0	4.0	8.8	76	
10	79-10-22	13:15	surface	5.5	9.8	88	7.0
			1.0	5.5	9.8	88	
			2.0	5.5	9.8	88	
			3.0	5.5	9.8	88	
			4.0	5.2	9.8	86	
			5.0	5.1	9.8	85	
			6.0	5.1	9.6	83	
	79-10-23	12:00	surface	4.2	11.3	94	6.0
			1.0	4.5	11.3	95	
			2.0	4.8	11.3	96	
			3.0	4.8	11.4	97	
			4.0	4.6	11.3	96	
			5.0	4.6	11.3	96	
	79-10-24	10:00	surface	4.0	8.8	75	7.0
			1.0	4.0	8.9	76	
			2.0	4.0	9.0	77	
			3.0	4.0	9.0	77	
			4.0	4.0	9.0	77	
			5.0	4.0	8.9	76	
			6.0	4.2	8.9	76	
11	79-10-22	13:45	surface	5.5	9.8	87	4.0
			1.0	5.4	9.8	87	
			2.0	5.1	9.8	85	
			3.0	5.0	9.8	85	
	79-10-23	12:35	surface	4.5	11.2	95	4.0
			1.0	4.3	11.3	94	
			2.0	4.0	11.3	94	
			3.0	4.0	11.4	95	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
11 cont'd.	79-10-24	10:30	surface	3.6	9.4	80	4.5
			1.0	3.8	9.5	81	
			2.0	3.8	9.4	81	
			3.0	4.0	9.3	79	
			4.0	4.0	9.3	79	
12	79-10-22	13:30	surface	5.4	10.0	88	4.0
			1.0	5.3	10.0	88	
			2.0	5.2	9.9	87	
			3.0	5.0	9.9	87	
	79-10-23	12:15	surface	4.8	11.2	97	1.5
			1.0	4.8	11.2	97	
	79-10-24	10:15	surface	4.3	8.7	74	1.5
			1.0	4.2	8.9	76	
13	79-10-22	13:35	surface	4.0	11.2	99	4.0
			1.0	4.0	11.2	99	
			2.0	3.8	11.2	99	
			3.0	3.8	11.1	98	
	79-10-23	12:25	surface	3.5	11.9	98	4.0
			1.0	3.5	12.0	99	
			2.0	3.3	12.0	98	
			3.0	3.2	12.2	99	
	79-10-24	10:20	surface	1.8	10.4	83	2.0
			1.0	1.8	10.3	82	
14	79-10-22	13:25	surface	5.0	9.9	86	4.0
			1.0	5.0	9.9	86	
			2.0	5.0	9.9	86	
			3.0	5.0	9.9	86	
	79-10-23	12:05	surface	3.0	11.8	98	4.0
			1.0	3.0	11.7	97	
			2.0	3.0	11.7	97	
			3.0	3.0	11.7	97	
	79-10-24	10:05	surface	3.8	9.2	78	4.0
			1.0	3.8	9.1	77	
			2.0	3.8	9.0	76	
			3.0	3.8	9.1	77	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
1	80-02-18	14:00	surface	0	9.2	69	2.0
			1.0	0	8.6	65	1.0 ice
			1.5	0	7.8	59	
	80-02-19	12:30	surface	0	8.6	65	2.1
			1.0	0	7.8	59	0.8 ice
	80-02-20	10:35	surface	0	9.1	68	2.0
			1.0	0	8.3	62	1.0 ice
2	80-02-18	14:10	surface	0	8.0	60	0.8
							0.8 ice
	80-02-19	12:45	surface	0	7.6	57	1.0
							0.8 ice
	80-02-20	10:45	surface	0	8.2	62	1.0
							1.0 ice
3	80-02-18	14:20	surface	0	7.8	59	1.1
							0.8 ice
	80-02-19	13:00	surface	0	7.2	54	1.5
							0.8 ice
	80-02-20	10:55	surface	0	6.5	49	1.0
							1.0 ice
4	80-02-18	14:30	surface	0	8.5	64	1.8
			1.0	0	8.0	60	0.8 ice
	80-02-19	13:05	surface	0	5.8	44	1.0
							0.8 ice
	80-02-20	11:00	surface	0	7.2	54	0.8
							0.6 ice
5	80-02-18	14:45	surface	0	4.0	30	0.8
							0.7 ice
	80-02-19	13:15	surface	0	4.2	32	0.8
							0.6 ice
	80-02-20	11:15	surface	0	3.4	26	1.0
							1.0 ice

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
6	80-02-18	14:45	surface	0	7.1	53	1.8
			1.0	0	6.0	45	0.8 ice
	80-02-19	13:25	surface	0	5.3	40	1.5
							0.8 ice
	80-02-20	11:20	surface	0	6.5	49	1.0
							1.0 ice
7	80-02-18	11:15	surface	0	5.5	41	2.7
			1.0	0	5.0	38	1.0 ice
			1.5	0	4.1	31	
	80-02-19	10:40	surface	0	5.0	38	2.0
			1.0	0	4.2	32	0.8 ice
	80-02-20	08:40	surface	0	6.0	45	2.3
			1.0	0	5.8	44	0.8 ice
			1.5	0	4.5	34	
8	80-02-18	13:43	surface	0	9.2	69	5.0
			1.0	0	8.6	65	1.0 ice
			2.0	0	8.3	62	
			3.0	0	8.2	62	
			4.0	0.5	8.1	62	
	80-02-19	12:25	surface	0	8.6	65	4.8
			1.0	0	8.2	62	0.8 ice
			2.0	0	7.6	57	
			3.0	0	7.2	54	
			4.0	0.5	6.8	52	
	80-02-20	10:25	surface	0	9.6	72	5.0
			1.0	0	9.0	68	1.0 ice
			2.0	0	8.2	62	
			3.0	0	8.0	60	
			4.0	0.5	7.6	57	
9	80-02-18	13:26	surface	0	5.8	44	6.0
			1.0	0	5.5	41	1.0 ice
			2.0	0.5	4.8	37	
			3.0	0.5	4.2	32	
			4.0	1.0	3.8	29	
			5.0	1.0	3.8	29	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
9 cont'd.	80-02-19	12:10	surface	0.5	4.3	33	6.0
			1.0	1.0	4.0	31	0.8 ice
			2.0	1.0	3.8	29	
			3.0	1.0	3.5	27	
			4.0	1.0	3.2	25	
			5.0	1.0	2.8	22	
	80-02-20	10:10	surface	0	6.2	47	6.0
			1.0	0	5.4	41	1.0 ice
			2.0	0	4.8	36	
			3.0	0.5	4.5	34	
			4.0	0.5	4.0	31	
			5.0	1.0	3.4	26	
10	80-02-18	11:30	surface	0	4.2	32	7.0
			1.0	0	3.5	26	1.0 ice
			2.0	1.0	3.4	26	
			3.0	2.0	2.8	22	
			4.0	2.0	2.5	20	
			5.0	2.5	1.7	14	
			6.0	2.5	0.5	4	
	80-02-19	10:56	surface	0	5.5	41	7.0
			1.0	0	4.5	34	0.8 ice
			2.0	0.5	4.0	31	
			3.0	1.0	3.4	26	
			4.0	1.0	3.1	24	
			5.0	1.0	1.6	12	
			6.0	2.0	1.1	9	
	80-02-20	08:56	surface	0	5.5	41	7.0
			1.0	0.5	5.1	39	1.0 ice
			2.0	1.0	4.5	35	
			3.0	1.0	4.3	33	
			4.0	1.0	4.1	32	
			5.0	1.5	2.3	18	
			6.0	2.0	1.2	10	
11	80-02-18	13:15	surface	0	6.5	49	5.0
			1.0	0	5.8	44	1.0 ice
			2.0	0.5	5.5	42	
			3.0	0.5	5.2	39	
			4.0	1.0	4.5	35	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
11 cont'd.	80-02-19	12:00	surface	0	5.8	44	5.0
			1.0	0.5	5.2	40	0.8 ice
			2.0	0.5	4.5	34	
			3.0	1.0	4.1	32	
			4.0	1.0	3.8	29	
	80-02-20	10:00	surface	0	7.5	56	5.0
			1.0	0	6.3	47	1.0 ice
			2.0	0	5.8	44	
			3.0	0.5	5.2	40	
			4.0	0.5	4.7	36	
12	80-02-18	12:50	surface	0	5.1	38	3.0
			1.0	0	4.4	33	1.0 ice
			2.0	1.0	4.2	33	
	80-02-19	11:26	surface	0	5.0	38	6.0
			1.0	0	4.5	34	0.8 ice
			2.0	0.5	4.1	31	
			3.0	0.5	3.8	29	
			4.0	1.0	3.6	28	
			5.0	1.0	2.4	19	
	80-02-20	09:30	surface	0	7.4	54	5.0
			1.0	0	6.8	52	1.0 ice
			2.0	0.5	5.6	43	
			3.0	0.5	5.2	40	
			4.0	1.0	4.0	31	
13	80-02-18	13:00	surface	0	5.0	38	5.0
			1.0	0	4.8	36	1.0 ice
			2.0	0	4.8	36	
			3.0	1.5	1.7	13	
			4.0	1.5	0.5	4	
	80-02-19	11:45	surface	0	7.6	57	4.0
			1.0	0	5.8	44	0.8 ice
			2.0	0	5.2	39	
			3.0	1.0	2.5	19	
	80-02-20	09:43	surface	0	5.8	44	5.0
			1.0	0	5.5	41	1.0 ice
			2.0	0	5.1	38	
			3.0	1.0	1.8	14	
			4.0	1.5	1.1	9	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
14	80-02-18	12:36	surface	2.0	5.1	41	5.0
			1.0	2.0	4.3	34	1.0 ice
			2.0	2.0	4.2	33	
			3.0	2.0	3.9	31	
			4.0	2.0	3.7	30	
	80-02-19	11:13	surface	0	4.1	31	4.8
			1.0	0.5	3.3	25	0.8 ice
			2.0	1.0	3.1	24	
			3.0	1.0	2.8	22	
			4.0	1.0	1.6	12	
	80-02-20	09:20	surface	0	5.5	41	4.0
			1.0	0	5.0	38	1.0 ice
			2.0	1.0	4.5	35	
			3.0	1.0	4.1	32	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
1	80-05-26	13:00	surface 1.0	20.0 19.8	7.9 8.4	95 101	1.2
	80-05-26	18:32	surface 1.0	20.0 20.0	7.8 7.7	94 93	1.0
	80-05-26	23:10	surface 1.0	19.5 19.5	8.0 8.0	95 95	1.0
	80-05-27	02:10	surface 1.0	18.5 18.2	4.0 3.1	47 36	1.0
	80-05-27	05:05	surface 1.0	18.5 18.0	5.9 4.7	69 54	1.0
	80-05-27	09:50	NR	NR	NR	NR	1.0
	80-05-27	12:30	surface 1.0	19.5 19.5	8.5 9.3	101 110	1.0
	80-05-28	08:35	surface 1.0	18.0 18.0	6.0 6.0	69 69	1.8
2	80-05-26	13:12	surface 1.0 1.5	19.0 19.0 19.0	7.8 8.0 8.1	92 94 95	1.5
	80-05-26	18:25	surface 1.0	19.0 19.0	8.3 8.2	98 98	1.1
	80-05-26	23:20	surface 1.0	19.3 19.5	7.8 7.8	93 93	1.0
	80-05-27	02:20	surface 1.0	18.5 18.0	3.7 2.5	43 29	1.0
	80-05-27	05:10	surface 1.0	18.0 18.0	4.3 4.3	49 49	1.0
	80-05-27	09:45	NR	NR	NR	NR	1.0
	80-05-27	12:25	surface 1.0	20.2 20.0	9.1 9.0	110 108	1.0
	80-05-28	08:30	surface 1.0	18.0 18.0	6.2 6.0	71 69	1.1

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
3	80-05-26	13:26	surface	19.0	7.7	91	1.5
			1.0	19.0	7.8	92	
			1.5	19.0	7.9	93	
	80-05-26	18:22	surface	21.0	7.2	88	1.0
			1.0	21.0	7.3	89	
	80-05-26	23:25	surface	18.5	8.0	95	1.0
			1.0	19.0	8.1	93	
	80-05-27	02:25	surface	18.0	4.8	56	1.0
			1.0	17.8	4.5	52	
	80-05-27	05:15	surface	17.5	5.4	61	1.0
			1.0	17.5	5.4	61	
	80-05-27	09:40	NR	NR	NR	NR	1.0
	80-05-27	12:12	surface	20.0	8.8	106	1.0
			1.0	19.8	9.1	110	
	80-05-28	08:25	surface	18.0	6.5	75	1.0
			1.0	18.0	6.6	76	
4	80-05-26	13:35	surface	19.0	7.6	89	1.4
			1.0	19.0	7.7	91	
			1.3	19.0	7.7	91	
	80-05-26	18:00	surface	19.5	7.2	86	1.5
			1.0	19.0	7.7	91	
			1.7	19.0	7.9	93	
	80-05-26	23:30	surface	19.0	8.1	95	1.0
			1.0	19.2	8.0	94	
	80-05-27	02:30	surface	18.0	4.6	53	1.0
			1.0	18.5	4.7	55	
	80-05-27	05:20	surface	17.8	6.0	69	1.0
			1.0	18.0	5.8	67	
	80-05-27	09:35	NR	NR	NR	NR	1.0
	80-05-27	12:20	surface	20.0	7.0	84	1.0
			1.0	20.0	7.2	87	
	80-05-28	08:20	surface	18.5	7.0	81	1.0
			1.0	18.5	7.0	81	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
5	80-05-26	14:45	surface 1.0	20.0 20.0	7.8 7.7	94 93	1.0
	80-05-26	17:50	surface 1.0	19.5 19.5	8.7 8.5	104 101	1.0
	80-05-26	23:37	surface 1.0	18.3 18.8	8.1 8.0	94 94	1.0
	80-05-27	02:35	surface 1.0	18.0 18.0	4.0 4.0	46 46	1.0
	80-05-27	05:25	surface 1.0	17.0 16.8	4.0 3.9	45 44	1.0
	80-05-27	09:30	NR	NR	NR	NR	1.0
	80-05-27	12:15	surface 1.0	20.5 20.5	8.0 8.2	96 99	1.0
	80-05-28	08:15	surface 1.0	18.0 18.0	8.1 8.3	93 95	1.0
6	80-05-26	15:00	surface 1.0	21.0 21.0	7.9 7.8	96 95	1.0
	80-05-26	17:45	surface	19.0	8.3	98	0.9
	80-05-26	23:50	surface 1.0	18.2 18.5	8.1 8.0	94 94	1.0
	80-05-27	02:40	surface 1.0	18.0 18.0	4.5 4.5	52 52	1.0
	80-05-27	05:30	surface 1.0	17.5 17.0	5.5 5.4	63 61	1.0
	80-05-27	09:25	NR	NR	NR	NR	1.0
	80-05-27	13:35	surface 1.0	20.2 19.5	8.4 8.5	101 101	1.0
	80-05-28	08:10	surface 1.0	18.5 19.0	8.2 8.0	95 94	1.0

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
7	80-05-26	15:10	surface	21.0	7.8	95	1.5
			1.0	20.0	7.7	93	
			1.5	20.0	7.7	93	
	80-05-26	17:35	surface	19.5	8.0	95	1.0
			1.0	19.5	8.2	98	
	80-05-26	24:00	surface	19.0	7.8	92	1.0
			1.0	18.8	7.8	92	
	80-05-27	02:45	surface	18.2	4.4	51	1.0
			1.0	18.5	4.3	50	
	80-05-27	05:35	surface	17.5	4.8	55	1.0
			1.0	17.5	5.2	59	
	80-05-27	09:15	NR	NR	NR	NR	1.0
	80-05-27	13:27	surface	19.5	8.4	100	1.0
			1.0	19.0	8.5	100	
	80-05-28	08:05	surface	18.5	8.2	95	1.2
			1.0	18.5	8.6	100	
8	80-05-26	14:35	surface	19.0	7.4	87	5.0
			1.0	19.0	7.3	86	
			2.0	19.0	7.2	85	
			3.0	19.0	7.2	85	
			4.0	19.0	7.3	86	
			5.0	19.0	7.3	86	
	80-05-26	18:37	surface	19.0	7.4	87	5.0
			1.0	19.0	7.4	87	
			2.0	19.0	7.3	86	
			3.0	19.0	7.2	85	
			4.0	19.0	7.2	85	
			5.0	19.0	7.2	85	
	80-05-26	23:00	surface	19.0	8.4	99	4.5
			1.0	19.0	8.2	96	
			2.0	19.5	8.4	100	
			3.0	19.5	8.3	99	
			4.0	19.5	8.2	98	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
8 cont'd.	80-05-27	02:05	surface	18.5	3.8	44	4.5
			1.0	18.5	3.8	44	
			2.0	18.8	3.9	46	
			3.0	19.0	3.9	46	
			4.0	19.0	3.9	46	
	80-05-27	05:00	surface	18.5	5.7	66	4.5
			1.0	18.5	5.6	65	
			2.0	18.3	5.7	66	
			3.0	18.3	5.9	69	
			4.0	18.3	6.0	70	
	80-05-27	09:52	NR	NR	NR	NR	6.0
	80-05-27	12:35	surface	18.7	7.0	81	5.0
			1.0	18.5	6.7	78	
			2.0	18.0	6.4	74	
			3.0	18.0	6.6	76	
			4.0	18.0	6.2	71	
			5.0	18.0	6.0	69	
	80-05-28	08:40	surface	18.0	5.7	66	5.0
			1.0	18.0	5.5	63	
			2.0	18.0	5.4	62	
			3.0	18.0	5.3	61	
			4.0	18.0	5.3	61	
			5.0	18.0	4.8	55	
9	80-05-26	14:00	surface	19.0	7.0	82	6.0
			1.0	19.0	7.1	84	
			2.0	19.0	7.1	84	
			3.0	18.7	7.2	85	
			4.0	18.6	7.2	85	
			5.0	18.5	7.2	85	
			6.0	18.5	7.3	86	
	80-05-26	18:15	surface	19.0	7.9	93	6.0
			1.0	19.0	7.5	88	
			2.0	19.0	7.4	87	
			3.0	19.0	7.4	87	
			4.0	19.0	7.7	91	
			5.0	19.0	7.5	88	
			6.0	19.0	7.5	88	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
9 cont'd.	80-05-26	22:50	surface	18.5	8.8	102	5.5
			1.0	19.0	8.6	101	
			2.0	19.5	8.4	99	
			3.0	19.5	8.6	102	
			4.0	19.5	8.8	105	
			5.0	19.5	8.5	101	
	80-05-27	02:00	surface	18.5	4.0	47	6.0
			1.0	18.5	4.2	49	
			2.0	18.8	4.1	48	
			3.0	18.8	4.2	49	
			4.0	18.8	4.0	47	
			5.0	18.5	4.0	47	
			6.0	18.7	3.9	46	
	80-05-27	04:55	surface	18.0	5.5	63	5.0
			1.0	18.0	5.4	62	
			2.0	18.3	5.5	64	
			3.0	18.5	5.6	65	
			4.0	18.5	5.8	67	
			5.0	18.0	5.7	66	
	80-05-27	09:55	NR	NR	NR	NR	6.0
	80-05-27	12:45	surface	18.5	7.2	84	6.0
			1.0	18.7	7.2	84	
			2.0	18.0	6.9	79	
			3.0	17.8	6.9	79	
			4.0	17.5	6.4	73	
			5.0	17.3	6.0	68	
	80-05-28	08:47	surface	18.5	5.5	64	5.8
			1.0	18.5	5.2	60	
			2.0	18.5	5.3	62	
			3.0	18.5	5.2	60	
			4.0	18.0	5.0	57	
			5.0	18.0	5.0	57	
			5.8	17.5	3.6	41	
10	80-05-26	15:20	surface	18.0	7.2	83	7.0
			1.0	17.5	7.2	82	
			2.0	17.5	7.2	82	
			3.0	17.5	7.2	82	
			4.0	17.5	7.2	82	
			5.0	17.5	7.2	82	
			6.0	17.5	7.2	82	
			7.0	17.5	7.2	82	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
10 cont'd.	80-05-26	19:50	surface	18.0	7.4	85	7.0
			1.0	18.0	7.1	82	
			2.0	18.0	7.0	80	
			3.0	18.0	6.7	77	
			4.0	18.0	6.8	78	
			5.0	18.0	6.5	75	
			6.0	18.0	6.4	74	
			7.0	17.5	6.4	74	
	80-05-26	22:00	surface	17.5	8.5	97	6.5
			1.0	18.5	8.7	101	
			2.0	18.7	8.7	101	
			3.0	18.9	8.7	102	
			4.0	18.9	8.9	105	
			5.0	18.9	8.0	94	
			6.0	19.0	8.5	100	
	80-05-27	01:20	surface	16.0	7.5	82	6.5
			1.0	17.0	6.7	75	
			2.0	17.0	6.6	74	
			3.0	17.0	6.5	73	
			4.0	17.5	6.4	73	
			5.0	17.5	6.4	73	
			6.0	17.5	6.2	70	
	80-05-27	04:15	surface	17.0	6.5	73	6.5
			1.0	17.2	6.4	72	
			2.0	17.2	6.2	70	
			3.0	17.7	6.2	70	
			4.0	17.8	6.3	72	
			5.0	18.0	5.9	68	
			6.0	18.0	5.6	64	
	80-05-27	10:25	NR	NR	NR	NR	7.5
	80-05-27	13:20	surface	18.4	7.0	81	7.0
			1.0	18.2	7.0	80	
			2.0	18.0	6.6	76	
			3.0	17.8	6.7	77	
			4.0	17.6	6.7	76	
			5.0	17.0	5.5	62	
			6.0	16.5	3.1	34	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
10 cont'd.	80-05-28	09:25	surface 1.0 2.0 3.0 4.0 5.0 6.0 6.6	18.0 18.0 18.0 18.0 18.0 18.0 17.5 16.5	7.4 7.3 7.3 7.3 7.2 7.1 6.4 4.2	85 84 84 84 83 82 73 47	6.6
11	80-05-26	16:00	surface 1.0 2.0 3.0 4.0 5.0	18.0 18.0 18.0 18.0 18.0 18.0	8.0 8.0 7.8 7.8 7.8 7.6	92 92 90 90 90 87	5.0
	80-05-26	18:50	surface 1.0 2.0 3.0 4.0 5.0	18.0 18.0 18.0 18.0 18.0 18.0	7.2 7.4 7.2 7.2 7.1 7.1	83 85 83 83 82 82	5.0
	80-05-26	22:40	surface 1.0 2.0 3.0 4.0	18.5 18.5 18.8 19.0 19.0	8.4 8.2 8.2 8.2 8.2	98 95 96 96 96	4.5
	80-05-27	01:50	surface 1.0 2.0 3.0 4.0	17.9 18.0 18.0 18.1 18.0	4.1 3.7 3.7 3.7 3.7	47 43 43 43 43	4.3
	80-05-27	04:50	surface 1.0 2.0 3.0 4.0	18.0 18.0 18.0 18.0 17.8	5.2 5.1 5.2 5.2 5.2	60 59 60 60 60	4.3
	80-05-27	10:00	NR	NR	NR	NR	5.0

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
11 cont'd.	80-05-27	12:55	surface	18.0	6.9	79	5.0
			1.0	18.0	6.9	79	
			2.0	18.0	6.7	77	
			3.0	18.0	6.5	75	
			4.0	17.6	6.1	69	
			5.0	17.5	5.9	67	
	80-05-28	08:55	surface	18.0	5.1	59	4.4
			1.0	18.0	5.1	59	
			2.0	18.0	5.0	57	
			3.0	17.5	4.7	53	
			4.0	17.5	4.1	47	
			4.4	17.5	4.0	45	
12	80-05-26	15:40	surface	17.5	7.8	89	2.0
			1.0	17.5	7.4	84	
			2.0	17.5	7.4	84	
	80-05-26	19:35	surface	17.0	8.0	90	3.2
			1.0	17.5	7.8	89	
			2.0	17.5	7.7	88	
			3.0	17.6	7.6	87	
	80-05-26	22:30	surface	18.0	8.0	92	5.0
			1.0	18.0	8.4	97	
			2.0	18.5	8.9	103	
			3.0	18.5	8.6	100	
			4.0	18.5	8.6	100	
			5.0	18.5	8.6	100	
	80-05-27	01:40	surface	18.0	4.1	47	6.0
			1.0	18.0	3.8	44	
			2.0	18.0	3.7	43	
			3.0	18.0	3.5	40	
			4.0	18.0	3.8	44	
			5.0	18.0	3.8	44	
			6.0	18.0	3.6	41	
	80-05-27	04:40	surface	17.8	5.2	60	2.4
			1.0	17.8	5.0	57	
			2.0	17.5	5.2	60	
	80-05-27	10:06	NR	NR	NR	NR	2.0

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
12 cont'd.	80-05-27	13:05	surface	17.9	7.0	80	2.0
			1.0	17.9	6.9	79	
			2.0	18.0	7.0	80	
	80-05-28	09:03	surface	18.0	4.8	55	2.0
			1.0	18.0	4.7	54	
			2.0	18.0	4.6	53	
13	80-05-26	15:50	surface	18.0	8.0	92	4.5
			1.0	18.0	7.8	89	
			2.0	18.0	7.7	89	
			3.0	17.5	7.7	89	
			4.0	17.5	7.6	87	
			4.5	17.0	7.6	87	
	80-05-26	19:30	surface	18.5	8.3	96	4.5
			1.0	18.5	7.9	92	
			2.0	18.2	7.4	86	
			3.0	18.2	7.3	84	
			4.0	18.0	7.5	86	
			4.5	18.0	7.3	84	
	80-05-26	22:20	surface	18.7	8.4	99	4.5
			1.0	19.0	8.2	96	
			2.0	19.0	8.2	96	
			3.0	19.0	8.2	96	
			4.0	19.0	8.5	100	
	80-05-27	01:35	surface	18.0	4.7	54	4.5
			1.0	18.0	4.6	53	
			2.0	18.5	4.6	53	
			3.0	18.2	4.0	46	
			4.0	18.0	3.8	44	
	80-05-27	04:35	surface	18.5	5.8	67	3.0
			1.0	18.2	5.6	64	
			2.0	18.0	5.4	62	
			3.0	18.0	4.8	55	
	80-05-27	10:10	NR	NR	NR	NR	4.5
	80-05-27	13:00	surface	18.2	7.3	84	4.5
			1.0	18.4	6.9	80	
			2.0	18.1	6.9	79	
			3.0	17.2	7.2	81	
			4.0	17.0	7.2	81	

Station	Date YR-MO-DY	Time HR:MIN	Depth Metres	Temperature °C	Dissolved Oxygen mg/L	Per Cent Saturation %	Total Depth
13 cont'd.	80-05-28	09:12	surface	18.0	4.2	48	3.9
			1.0	18.0	4.2	48	
			2.0	18.0	4.2	48	
			3.0	18.0	4.1	47	
			3.9	18.0	4.0	46	
14	80-05-26	15:35	surface	18.0	7.6	87	4.5
			1.0	18.0	7.4	85	
			2.0	18.0	7.3	84	
			3.0	17.5	7.4	84	
			4.0	17.5	7.3	83	
			4.5	17.5	7.3	83	
	80-05-26	19:45	surface	18.0	7.8	90	4.0
			1.0	18.0	7.8	90	
			2.0	18.0	7.7	89	
			3.0	18.0	7.7	89	
			4.0	18.0	7.8	90	
	80-05-26	22:10	surface	18.5	8.7	101	3.0
			1.0	18.5	8.4	98	
			2.0	18.5	8.5	100	
			3.0	18.5	8.5	100	
	80-05-27	01:30	surface	17.8	5.4	62	4.0
			1.0	17.8	5.0	57	
			2.0	17.9	4.8	55	
			3.0	18.0	4.8	55	
			4.0	18.0	4.6	53	
	80-05-27	04:25	surface	17.8	5.8	68	4.0
			1.0	17.8	5.5	63	
			2.0	18.0	5.5	63	
			3.0	18.0	5.6	64	
			4.0	18.0	5.6	64	
	80-05-27	10:17	NR	NR	NR	NR	4.5
	80-05-27	13:13	surface	18.0	6.8	78	4.0
			1.0	18.0	6.9	79	
			2.0	17.5	6.8	77	
			3.0	17.2	6.9	78	
			4.0	17.0	7.0	79	
	80-05-28	09:20	surface	18.0	7.4	85	4.4
			1.0	18.0	7.3	84	
			2.0	18.0	7.3	84	
			3.0	18.0	7.2	83	
			4.0	17.5	7.1	82	
			4.4	17.5	6.7	77	

APPENDIX D

DATA SUMMARIES FOR INORGANIC VARIABLES

LIST OF TABLES

APPENDIX D

Table D-1 Mean pH Values

Table D-2 Mean Conductivity Values

Table D-3 Mean Chloride Concentrations

Table D-4 Mean Iron Concentrations

Table D-5 Mean Manganese Concentrations

TABLE D-1

Mean pH Values
(pH units)

	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	8.8	8.8	8.7	8.8	8.8
2	8.9	8.7	8.7	8.8	8.8
3	8.7	8.8	8.6	8.8	8.8
4	8.9	8.8	8.6	8.8	8.8
5	8.9	8.8	8.5	8.8	8.8
6	8.8	8.8	8.6	8.8	8.8
7	8.9	8.8	8.6	8.8	8.8
8	8.8	8.8	8.6	8.8	8.8
9	8.8	8.8	8.6	8.8	8.8
10	8.8	8.8	8.6	8.8	8.8
11	8.8	8.8	8.6	8.8	8.8
12	8.8	8.8	8.6	8.8	8.8
13	8.7	8.8	8.5	8.8	8.7
14	8.8	8.8	8.6	8.8	8.8
Stations 1 through 14 inclusive	8.8	8.8	8.6	8.8	8.8
Inst.Min.	7.8	8.7	8.4	8.8	7.8
Inst.Max.	9.1	8.8	8.7	8.9	9.1

TABLE D-2

Mean Conductivity Values
(us/cm)

	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	1790	1800	2200	1900	1879
2	1811	1800	2133	1900	1880
3	1822	1800	2067	1822	1874
4	1775	1800	2150	1889	1880
5	1836	1800	2467	1900	1945
6	1800	1800	2167	1900	1883
7	1806	1800	2275	1900	1918
8	1863	1800	2133	1900	1905
9	1850	1800	2100	1900	1895
10	1838	1800	2183	1900	1984
11	1856	1800	2200	1900	1909
12	1871	1817	2167	1900	1917
13	1850	1800	2257	1900	1967
14	1825	1800	2200	1900	1925
All Stations Combined	1827	1801	2197	1898	1913
Inst.Min.	1600	1800	1800	1800	1600
Inst.Max.	2000	1850	2600	1900	2600

TABLE D-3

Mean Chloride Concentrations
(all values mg/L)

	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	17	17	19	14	16
2	16	18	18	14	16
3	16	17	19	13	15
4	16	18	19	14	16
5	17	23	20	14	17
6	16	16	19	13	15
7	16	16	19	13	15
8	17	15	19	14	16
9	17	16	18	14	16
10	16	18	19	13	16
11	16	17	19	14	16
12	16	17	19	14	16
13	17	19	19	14	16
14	17	17	19	13	16
All Stations Combined	16	17	19	14	16
Inst.Min.	10	12	18	10	10
Inst.Max.	20	36	20	18	36

TABLE D-4

Mean Iron Concentrations
(all values mg/L)

	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	0.2	0.1	-	0.3	0.2
2	0.1	0.4	-	0.2	0.3
3	0.1	0.3	-	0.1	0.2
4	0.1	0.3	-	0.2	0.2
5	0.2	0.2	-	0.2	0.2
6	0.2	0.2	-	0.3	0.2
7	0.1	0.1	-	0.1	0.1
8	0.1	0.2	-	0.1	0.1
9	0.1	0.1	-	0.1	0.1
10	0.1	0.6	0.1	0.1	0.2
11	0.1	0.8	-	0.2	0.3
12	0.1	0.1	-	0.1	0.1
13	0.1	0.2	0.6	-	0.3
14	0.1	0.1	-	0.2	0.1
All Stations Combined	0.1	0.3	0.2	0.3	0.2
Inst.Min.	<0.1	<0.1	<0.1	<0.1	<0.1
Inst.Max.	0.5	2.2	2.8	2.7	2.8

TABLE D-5

Mean Manganese Concentrations
(all values mg/L)

	August 13-15/79	October 22-24/79	February 18-20/80	May 26-28/80	All Surveys Combined
1	0.02	0.01	-	0.02	0.02
2	0.01	0.01	-	0.02	0.01
3	0.01	0.01	-	0.03	0.02
4	0.01	0.01	-	0.03	0.02
5	0.01	0.01	-	0.01	0.01
6	0.02	0.01	-	0.05	0.03
7	0.02	0.01	-	0.01	0.01
8	0.02	0.01	-	0.01	0.01
9	0.02	0.01	-	0.01	0.01
10	0.02	0.01	0.03	0.02	0.02
11	0.02	0.01	-	0.02	0.02
12	0.02	0.01	-	0.01	0.01
13	0.01	0.01	0.02	0.01	0.02
14	0.02	0.01	0.04	0.01	0.02
All Stations Combined	0.01	0.01	0.03	0.01	0.02
Inst.Min.	<0.01	<0.01	0.01	<0.01	<0.01
Inst.Max.	0.03	0.02	0.10	0.08	0.10